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SPEED MANAGEMENT

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EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT (ECMT)

The **European Conference of Ministers of Transport** (ECMT) is an inter-governmental organisation established by a Protocol signed in Brussels on 17 October 1953. It comprises the Ministers of Transport of 43 full Member countries: Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, FRY Macedonia, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia and Montenegro, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine and the United Kingdom. There are seven Associate member countries (Australia, Canada, Japan, Korea, Mexico, New Zealand and the United States) and one Observer country (Morocco).

The ECMT is a forum in which Ministers responsible for transport, and more specifically inland transport, can co-operate on policy. Within this forum, Ministers can openly discuss current problems and agree upon joint approaches aimed at improving the use and ensuring the rational development of European transport systems.

At present, ECMT has a dual role. On one hand it helps to create an integrated transport system throughout the enlarged Europe that is economically efficient and meets environmental and safety standards. In order to achieve this, ECMT assists in building bridges between the European Union and the rest of the European continent at a political level. On the other hand, ECMT also develops reflections on long-term trends in the transport sector, and more specifically, studies the implications of globalisation on transport.

In January 2004, the ECMT and the Organisation for Economic Co-operation and Development (OECD) brought together their transport research capabilities by establishing the **Joint Transport Research Centre**. The Centre conducts co-operative research programmes that address all modes of inland transport and their intermodal linkages to support policy-making throughout member countries.

Also available in French under the title:
La gestion de la vitesse

Further information about the ECMT is available on Internet at the following address:
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FOREWORD

Speeding on the roads is a serious societal and public health issue in all countries.

This project assesses the extent and impact of speeding in member countries, drawing on research results and experience to date and takes into account the responses from 23 OECD and ECMT countries to a survey conducted as part of the study.

The report focusses on the key issues related to speeding including road safety fatalities and injuries and adverse environmental impacts, highlights the policy and operational improvements needed and outlines a policy framework for reducing the extent of speeding on the roads. The report puts forward research-based, policy-oriented recommendations for addressing the wide-spread problems with speeding and its adverse impacts on fatalities and injuries as well as its impacts on the environment and the general quality of life in developed areas.

The Speed Management report is the result of two years of work by a group of expert researchers in the field of road traffic safety from many Organisation for Economic Co-operation and Development (OECD) and European Conference of Ministers of Transport (ECMT) countries. Working group members came from Australia, Canada, the Czech Republic, Finland, France, Germany, Greece, Hungary, Iceland, Korea, the Netherlands, Norway, Portugal, Sweden, the United Kingdom and the United States. A complete list of participants is provided in the Appendix.

The Joint OECD/ECMT Transport Research Centre was established in January 2004. It has 50 full member countries and reports directly to Ministers, as well as to the OECD Council. The Mandate of the Centre is as follows:

> *"The Centre shall promote economic development and contribute to structural improvements of OECD and ECMT economies, through co-operative transport research programmes addressing all modes of inland transport and their intermodal linkages in a wider economic, social, environmental and institutional context"*.

This report is one of three road safety reports prepared concurrently by the Joint OECD/ECMT Transport Research Centre, along with *Achieving Ambitious Road Safety Targets* and *Young Drivers: The Road to Safety.*

It is hoped that this report will assist policy-makers, road safety professionals and researchers in addressing comprehensively the speeding problem, thereby reducing the overall impact of traffic crashes on individuals, families, communities and societies.

TERMINOLOGY USED IN THIS REPORT

Throughout this report, the following terminology will be used:

- *Excessive speed* means speeds above a prescribed speed limit.
- *Inappropriate speed* means speeds too high for the prevailing conditions, but within the speed limit.
- *Speeding* encompasses both excessive and inappropriate speed.

Accident / Crash

The working group decided to use the term "accident" throughout the report, as it reflects the terminology used in the majority of the participating countries. It is synonymous, in this report, to the word "crash" widely used in North America and other regions.

ABSTRACT
ITRD* NUMBER E130442

Speeding - which encompasses *excessive speed* (*i.e.* driving above the speed limits) or *inappropriate speed* (driving too fast for the prevailing conditions, but within the limits) - is dangerous. As well as being a causation factor in around one third of fatal accidents, speed is an aggravating factor in the severity of all accidents. It has also serious consequences on the environment and energy consumption. Speed management can be defined as a set of measures to limit the negative effects of excessive and inappropriate speeds.

This report is the output of an expert Working Group which worked over a period of 2 years and conducted an in-depth survey on speed management practices in OECD/ECMT countries. It analyses the effects of speed on safety but also on the environment and the quality of life and assesses the extent of speeding in OECD/ECMT countries. It reviews speed management measures including: infrastructure, signs and signing, vehicle technologies, education and training, enforcement and new technologies, such as intelligent speed adaptation. Finally, it describes how individual measures can be combined in the framework of a speed management policy and highlights the specific needs of developing countries in terms of speed management.

Subject Classification: Accidents and the human factor; Environment

Subject Codes: 83; 15

Keywords: accident, behaviour, cause, developing countries, driver, enforcement (law), environment, fatality, offence, policy, research project, severity (accident, injury), social cost, speed, speed limit, speed limiter, technology, traffic restraint, traffic sign.

* The International Transport Research Documentation (ITRD) database of published information on transport and transport research is administered by TRL on behalf of the Joint OECD/ECMT Transport Research Centre. ITRD contains over 350 000 bibliographical references, and about 10 000 are added each year. Input to the ITRD database is provided by more than 30 renowned institutes and organisations from around the world. For more details about ITRD, please contact itrd@trl.co.uk or see the ITRD website at: www.itrd.org.

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EXECUTIVE SUMMARY

Over the past five decades, society and individuals have benefited greatly from rapidly improving road systems. During the same period, industry has manufactured and sold motor vehicles able to travel at increasingly high speeds. Higher speed vehicle transport has contributed to the economic development of OECD/ECMT countries, and has contributed to improvements in the general quality of life. On the other hand, these higher vehicle speeds have had major adverse impacts, principally in terms of road accidents - and consequent death, injury, and material damage but also in environmental terms including noise and exhaust emissions and in terms of the liveability of residential and urban areas.

Recently, there has been increasing demand, particularly in urban areas, for strategies that reduce such adverse impacts. A growing portion of the population has sought to improve road safety, reduce adverse environmental impacts and improve the general quality of life. In urban areas in particular, residents are increasingly in favour of lowering vehicle speeds in order to protect the environment, provide a better level of amenity for the general resident population, better protect those living near roads, and in particular ensure the safety of pedestrians, bicyclists, children and people with reduced mobility.

Speed management policies which can deliver these outcomes have become a high priority in many countries.

The effects of speed

Speed has many positive impacts, the most obvious being that it allows a reduction in journey time and therefore enhances mobility. Advances over the past century in roads, motor vehicles and road transport have decreased travel times significantly – and have also contributed to the development of national economies, facilitated access to employment, goods and services and facilities such as hospitals, entertainment and shopping centres, and in turn widened opportunities for housing, jobs, etc. These advances have clearly contributed to improvements in the general quality of life.

Speed also has some strong negative consequences (e.g. on road safety and the environment) and can contribute to significant adverse impacts on the liveability of residential and urban areas.

The problem of speed

Excessive and inappropriate speed is the number one road safety problem in many countries, often contributing to as much as one third of fatal accidents and an aggravating factor in all accidents

Speeding - which encompasses *excessive speed* (*i.e.* driving above the speed limits) or *inappropriate speed* (driving too fast for the prevailing conditions, but within the limits) - is dangerous. As well as being a causation factor in around one third of fatal accidents, speed is an aggravating factor in the severity of all accidents.

As the impact speed increases, the forces that vehicle occupants must absorb in a crash increase dramatically, in accordance with kinetic energy principles. Occupant protection systems are very effective at low and moderate speeds. However, they cannot adequately protect vehicle occupants from these kinetic forces at high impact speeds.

Vulnerable road users are particularly exposed to vehicle impacts - especially in urban areas - at speeds which are above the limits of human tolerance.

Excessive speed is a widespread social problem, which affects the entire road network (motorways, main highways, rural roads, urban roads). Typically, at any time, 50% of drivers are above the speed limits. Often, drivers exceed speed limits by less than 20 km/h. but a proportion of drivers travel at speeds more than 20 km/h above the limit. Speeding concerns all types of motor vehicles and all groups of road users. However, young drivers are the group the most involved in speeding behaviour.

The significant adverse road safety impacts of higher vehicle speeds have been confirmed by extensive research. The relationship between serious injury accidents, fatal accidents and speed has been modelled by many researchers. Nilsson's "Power Model"[1] which is well known leads to the broad relationships illustrated in the chart and the following estimates of the effects of changes in mean speed on fatal accidents, fatal and serious injury accidents and all injury accidents:

- A 5 % increase in average speed leads to approximately a 10 % increase in all injury accidents and a 20 % increase in fatal accidents.

The same research indicates the positive impacts of reducing vehicle speeds:

- A 5 % decrease in average speed leads to approximately a 10 % decrease in injury accidents and a 20 % decrease in fatal accidents.

Source: Nilsson (2004).

As the model indicates, reducing speed by a few km/h can greatly reduce the risks of accidents as well as mitigating the consequences of an accident[2].

1. Any model is a simplified representation of reality. The Nilsson model of the relationship between vehicle speed and fatalities and injuries, while founded on a sound scientific base, can not take into account all the characteristics of the road environment. The actual effects depend on the exact road traffic and characteristics. For example, the effect is considerably larger on urban roads as compared to motorways.

2. As an example, in Melbourne (Australia), when the speed limit on the rural freeway network was increased from 100 to 110 km/h in 1987, the injury accidents increased by 24.6%. When the speed limit changed back to 100 km/h in 1989, the injury accidents decreased by 19%.

Recognising the broad concerns about speeding, the Secretary-General of the United Nations, in his report[3] to the General Assembly on *Improving global road safety,* has invited member States to "take action on inappropriate and excessive speed".

Higher vehicle speeds also contribute to increased greenhouse gas emissions, fuel consumption and noise and to adverse impacts on quality of life especially for people living in urban areas

Speed has important impacts on the environment as it is strongly related to the emissions of greenhouse gases (mainly CO_2) and of local pollutants (CO, NOx, HC, particulates), as well as to increasing fuel consumption. Ozone - which comes from chemical reactions involving hydrocarbons, oxides of nitrogen, and sunlight - is thus affected by vehicle emissions and therefore by vehicle speeds.

Speed also has a considerable impact on the exterior noise that a vehicle emits and therefore on overall levels of traffic noise, which are another major concern, particularly in urban areas and at night time.

Travel speed, actual and perceived, can also affect - both positively and negatively - people's assessments of their level of amenity.

Greater mobility, faster travel, and better access to facilities and services improve general assessments of the quality of life, while the significant adverse impacts such as on the environment detract from such quality of life. Some impacts such as injury or noise can be measured; others are more difficult to assess. Disruption to local communities, or fear of fast moving vehicles, which may discourage individuals from walking or cycling, or restrict their ability to reach destinations easily, are not readily quantifiable but can still have a considerable impact on the people concerned. In these cases, the social costs of speed are borne mainly by those outside moving vehicles.

Speed management is not incompatible with mobility and economic needs

Mathematically, higher speed leads to reduced travel time. However, the effects of speed in reducing travel time are generally overestimated by road users and, at least in urban areas, the time savings are often small or negligible because of intersections and delays at traffic lights.

In terms of infrastructure use, reducing the average speed of the flow does not necessarily reduce the throughput capacity of the road. For example, the maximum capacity of an urban motorway is typically obtained at a speed of about 60-70 km/h.

How to address the problem of speeding

Most governments have recognised the need for action to address speeding. *Speed management,* which should be a central element of any road safety strategy, aims to achieve appropriate speeds on all parts of the road network.

Speed management strategies and policies are often consistent with policy goals in other areas (*e.g.* protecting the environment) and may be embedded in wider transport strategies. These goals need to be made more prominent in order to encourage greater collaboration and cooperation and to increase public acceptance and political readiness to take action.

3. United Nations General Assembly, Document A/60/121 dated 1 August 2005.

With appropriate political support, speed management strategies can make a real contribution to achieving the triple goals of improved road safety, reducing environmental impacts and moderating energy consumption.

A very important and relatively recent development in addressing the problem of speeding has been to recognise and act on the thresholds of physical resistance of the human body to the energy released during a crash (which is related to the impact speed). These thresholds need to become a critical input to the development of laws, regulations and infrastructure. For example, according to the World Health Organisation, pedestrians incur a risk of around 80% of being killed at an impact speed of 50 km/h, while this risk is reduced to 10% at 30 km/h. For car occupants, wearing seat-belts in well designed cars can provide protection to a maximum of 70 km/h in frontal impacts and 50 km/h in side impacts.

Co-ordinated actions should be taken by the responsible authorities to bring about an immediate and durable response to the problem of speeding

Reduced speeding will immediately reduce the number of fatalities and injuries on the roads and is one guaranteed way to make real progress towards the ambitious road safety targets set by some OECD/ECMT countries (*e.g.* the -50% fatalities target adopted by ECMT Ministers in 2002 for the period 2000 to 2012 and other similar targets set at national level).

Recently, there have been a number of very successful examples of responsible authorities taking decisive and coordinated action to reduce speeding. Two of these are:

- ***France.*** On 14th July 2002 – the national holiday in France – the French President announced that the “fight against road unsafety” would be one of the government's three main objectives for the following five years. A year later, a road safety action plan – which involved several ministries – was adopted which included a strong focus on speed enforcement, with the introduction of automatic enforcement. Over three years from 2002, the average speed on French roads decreased by 5 km/h and fatalities decreased by over 30% in France – an unprecedented result.

- ***Australia.*** In 2002, the State of Victoria launched their *Arrive Alive!* Strategy, which also had a strong focus on lowering vehicle speeds. Stronger enforcement and a reduced tolerance margin for speed limit excedence led to noticeable decreases in the average speed, especially in 60, 70 and 80 km/h zones. During the first four years of the strategy (2002-2005), there was a reduction of around 16% in fatalities. The 43% reduction in fatalities in metropolitan Melbourne from 2001 to 2003 was spread across all road user categories. Even though it is difficult to conclude that the reduction in road trauma was solely due to improved compliance with speed limits, patterns of the injury and fatality reduction suggested that this was a major contributor to the trauma reduction.

As well as achieving rapid improvements in road safety, addressing speeding problems in these ways will make a significant contribution to the objective of reducing greenhouse gas emissions.

Reduced speeding will also reduce other adverse impacts which affect people’s perceptions of their amenity and quality of life – including vehicle noise, disruption to local communities, and less visible impacts such as the extent to which fast moving vehicles discourage individuals from walking or cycling, or restrict their ability to reach their destinations easily.

Development of a speed management package that achieves the right balance between the individual speed management measures

The speed management package will need to consider the following elements: infrastructure improvement, speed limits, appropriate signing and marking, vehicle engineering, education, training and incentives, enforcement and driving assistance technologies. In addition, a key element of the success of speed management policy is the measurement of speed. All countries are encouraged to monitor speed on their road network regularly, as this is a major performance indicator with respect to both safety and environmental objectives.

- *Education and information to the public and policy makers about the problem of speeding*

This is a prerequisite for the successful implementation of speed management actions. The most successful education and information programmes encompass the logical basis of the speed limit system, and the reasons for speed management measures, highlighting the positive safety outcomes of these measures, as well as the environmental benefits (air pollution and noise) of moderated speeds.

Education, training and information programmes are matters of concern to the entire population. However, different actions are required where children, teenagers, young drivers or drivers in general are concerned. Education and training of learner drivers needs to focus on the risks and other disadvantages of speeding so that these become an explicit issue in driver training. It is important that the driving instructors themselves are educated on the issue of speed and its effects.

Drivers who are already licensed form the largest group of interest, but they are also very difficult to reach. Countries generally rely on information campaigns, *e.g.* by billboards alongside the road or messages on television. Information campaigns are indispensable when used to support other measures but will have little effect if they are applied as a stand-alone measure.

The production and dissemination of information should be a continuous activity.

At the same time, advertisements for cars should not glamorize speed, as is currently often the case. The depiction of speed in advertising of cars, motorcycles and even sport utility vehicles (SUVs), both in print and television media, is widespread but should be actively discouraged. Rapid progress could be made through voluntary agreements on new advertising standards. Governments need to encourage manufacturers to replace the emphasis on speed with positive messages about the benefits of vehicle features and technologies that can improve safety while reducing journey times and the stress of driving. NCAP crash test programmes are examples of structured information schemes that governments could use to encourage manufacturers to offer safety-related speed management systems on new vehicles and to inform the public of their potential benefits.

- *Appropriate speeds for all types of roads in the network and review of existing speed limits*

Appropriate speeds for different types of roads should reflect the fundamental importance of protecting human life and preventing injury on the roads. The assessments need to be related to human tolerance to impact speeds in different potential crash circumstances and the risks of such crashes. Assessments of appropriate speed also require a trade off between other goals such as sustainable mobility, environmental protection and improved quality of life. Appropriate speeds need to be determined for all types of roads in the network. Existing speed limits then need to be reviewed to assess whether they reflect the appropriate speed in relation to accident risks and a the range of other relevant factors including road function, traffic composition, presence of vulnerable road users, and road design and roadside characteristics.

Speed limits are one way to achieve appropriate speeds. The speed limits chosen must be credible in the light of the road and road environment characteristics and public authorities have the responsibility of ensuring this credibility. There should be a clear differentiation between speed limits on motorways and other roads in order to maintain the attractiveness of the motorway which is the safest road category.

In urban areas, speed limits should not exceed 50 km/h[4] with 30 km/h zones promoted in areas where vulnerable road users (including children) are particularly at risk. Research shows that these lower limits, when accompanied by traffic calming measures, are very effective at reducing accidents and injuries, with reductions of up to two thirds having been demonstrated. In the last decade, a number of countries have lowered their speed limits in urban areas, with significant results in terms of reductions in fatalities. As an example:

- **Hungary.** The speed limit in force inside built up areas was reduced from 60 km/h to 50 km/h in 1993 and resulted in a reduction of 18.2% in accident fatalities in the following year.

Harmonised speed limits across regions (*e.g.* Europe, North America) can contribute to their improved credibility and promote an increasing level of acceptance among the general public.

The use of variable speed limits in appropriate circumstances may help to improve levels of safety performance and also improve public acceptance.

- *Drivers informed at all times on what the speed limit is*

Drivers need to be informed at all times on what the speed limit is. A traditional and cost-effective way is to use consistent roadside signing and road markings and much progress can still be made in their application.

As well, there are emerging technology applications which could allow the speed limits to be confirmed in other ways. For example, variable signs can deliver messages suited to the current road conditions, and are therefore more credible than fixed signs. Speed limits can also be displayed in the vehicle, through infrastructure-vehicle communication or through GPS systems.

- *Infrastructure improvements which aim to achieve safe,"self-explaining" roads*

Each road should have a clear function: access, distribution or flow. For each of these functions, there is a corresponding appropriate speed, which should derive logically from aspects of the infrastructure design, such as visibility distances, intersection spacing, and width of the right of way. This contributes to safe, "self explaining" roads, where drivers recognise the type of road and are guided to adapt their speed to the local conditions.

Infrastructure improvements are often easier and cheaper to implement in built-up areas, where immediate safety benefits can be made. Research has proven that measures such as speed humps and road narrowing are likely to be cost-effective in protecting vulnerable road users and the general environment, particularly in dwelling areas, near schools, at pedestrian crossings, etc.

On rural roads, infrastructure speed management measures are more difficult to implement because of the extent of the network and the costs involved. Improvements can be made by removing

4. In 1996, ECMT Ministers recommended considering a maximum speed limit of 50 km/h in urban areas, however this limit is still not implemented in some ECMT countries.

roadside obstacles with the aim of making the road safer and more ‘forgiving’. While the ideal solution would be to separate traffic on rural roads (using median barriers for example), resource constraints generally prevent this being done widely. Alternative solutions, such as the possible use of new technologies, should therefore be pursued as well.

When the infrastructure cannot be upgraded, at reasonable costs, to the standard required for the existing speed limit, the appropriate action is to *lower the speed limit*.

- *Appropriate level of traditional police enforcement and automatic speed control*

Both traditional police enforcement and automated speed control, including the use of mobile cameras - backed up by effective penalties - are needed to complement the other speed management measures in order to achieve their full effect.

Enforcement should encompass all road users (including foreign drivers) and all types of vehicles (*e.g.* motorcycles and trucks). In the case of automatic enforcement, experience has shown that better results are obtained when the vehicle owner, who is easier to identify than the driver, can be legally responsible for the violation[5].

Section control (*i.e.* control of average speed on a section of road) has proven to be a cost-effective way to enforce speed limits, suggesting that further experience should be encouraged.

Tolerance levels for speed limit excedence should be set at a minimum (*e.g.* 5%), allowing for possible inaccuracies of the measurement device and speedometers. Setting higher tolerance levels above speed limits gives a misleading signal to the drivers and makes the speed limit system less credible.

Randomness of enforcement is a major determinant of a driver’s subjective assessment of risk of apprehension. Therefore, an “anywhere anytime” enforcement programme could be expected to have more wide ranging effects, especially if linked to extensive publicity.

Experience with automatic control has shown that it is a cost effective approach which has a safety impact at a network level and not only at the location of the cameras[6]. However, a prerequisite to the successful large scale implementation of automatic speed cameras is provision of adequate information to the media, interest groups and the public. Re-investment of the revenues from fines in the enforcement effort (including speed camera operation) will reinforce that the purpose of automatic control by speed cameras is to improve road safety and raise public support.

- *Development of vehicle engineering*

Maximum speeds of passenger cars, light trucks, sport utility vehicles and motorcycles have increased greatly over the past 30 years. Almost all passenger cars sold in 2006 can go beyond 150 km/h which is above the maximum regulatory speed limit in almost all countries. At some stage, limitations on the maximum speed of vehicles may need to be considered. However, even such limitations would not solve all the speed problems – especially in urban areas, where limitations on maximum vehicle speed would be of little assistance in ensuring compliance with speed limits of 50 and 30 km/h.

5. In some countries (*e.g*. Germany), it is necessary to identify the drivers who committed the offence.

6. As an example, in France, the introduction of an automatic control sanction system in 2003 contributed to a reduction by 22 % of national road fatalities in 2004.

In countries with no such mandatory system, consideration should be given to mandatory speed limiters for trucks and coaches.

Conventional cruise control (CCC) and adaptive cruise control (ACC) can help drivers control vehicle speed. Adaptive cruise control – which allows the vehicle to follow a vehicle in front and maintain a pre-selected time gap or headway (distance) is a very promising technology that can help improve safety outcomes.

Electronic stability control (ESC or ESP) has proven very effective in reducing accident risk – particularly in the case of single vehicle accidents. The wider introduction of electronic stability control on passenger vehicles should be strongly encouraged.

Event data recorders (EDR) can deliver significant road safety benefits. EDRs can record data elements prior, during, and after an accident, including vehicle speed, acceleration, air bag deployment and some other occupant-based variables. More sophisticated EDR systems that transmit vehicle operational data including speed to fleet management centres are widely used in commercial vehicle fleets, particularly in North America. EDR's can be expected to promote a degree of "self enforcement". Their wider deployment also needs to be encouraged.

- *Development and progressive implementation of driver assistance and vehicle speed control technologies*

As *new technologies* become available progressively, new applications will provide a logical step forward in speed management. At present, Intelligent Speed Adaptation (ISA) applications are being actively researched and tested in many countries. With ISA technology, the vehicle "knows" the local speed limit and is capable of using that information to give feedback to the driver or limit the vehicle speed.

Two broad ISA categories are being assessed for possible wider deployment:

- *Informative (advisory)* ISA, which principally displays the speed limit and warns (via a sound or a visual element) the driver when above the speed limit; and

- *Supportive (intervening) ISA*, which provides advice to the driver but is also intervening in the sense that information on the speed limit is directly linked to the vehicle speed control system, with feedback to the driver.

Both systems can be set voluntarily (the driver chooses to activate it) or be made mandatory (the system is activated all the time). Whatever system is chosen, the driver can always override it in emergency situations.

Given the great potential benefits that such new technologies can bring, progressive implementation is encouraged on a cost-effectiveness basis. Appropriate actions could include:

- All new cars equipped with manually adjustable speed limiters (where the driver can choose the maximum speed)[7], and as soon as practicable with voluntary informative or supportive ISA, to assist drivers to adhere to speed limits (static and eventually variable).

7. Adjustable speed limiters are increasingly available on new passenger cars in Europe and Asia. In other regions, notably North America, such devices are currently not well known.

- Reflecting the potential substantial safety benefits, mandatory ISA applications are given further consideration for the longer term, recognising and taking into account the changes in philosophies and liabilities that could be involved (for the supportive systems)[8].

- To help secure the potential benefits of the promising new ISA technologies, governments are encouraged to start developing, in co-operation with relevant partners, the necessary digital speed limit databases. These databases could well have other uses (e.g. for traffic management).

Other new technologies

The long-term vision is of an intelligent highway where communication between individual vehicles and roadside infrastructure assists drivers or even actively controls vehicles from the roadside - this may be of most benefit on strategic road networks. Other systems will be based on communication between the vehicles and satellites. For the longer term, there are a number of other technological advances that can be expected to provide real opportunities to greatly reduce the number of collisions, and ultimately the number and severity of casualties.

It is important that individual countries, and pan-European and world forums, continue to research these emerging opportunities so that informed decisions can be made. Appropriate research must be conducted to ensure that increased use of technology does not compromise safety and before full implementation, a number of issues need to be solved, including an in-depth assessment of potential adverse effects. Political and policy support will be important.

Situation in developing countries

Speeding is also a growing concern for developing countries. There is not enough data or research to clearly quantify the situation with respect to speeding in many countries at different stages of development, however, increasing levels of motorization without an adequate focus on speeding can be expected to have serious consequences for road safety. Although local circumstances will differ, the experience of OECD/ECMT countries could be very useful, allowing developing countries access to the lessons learnt from years of experience with speed management policies. While Governments from industrialised countries can help with the transfer of the knowledge required developing countries will need to adapt the measures to the culture, level of development and level of road safety in each country.

Conclusions

Reduced speeding will immediately reduce the number of fatalities and injuries and is a guaranteed way to make real progress towards the ambitious road safety targets set by OECD/ECMT countries. Co-ordinated actions by the responsible authorities can bring about an immediate and durable response to the problem of speeding.

The best approach is to develop a comprehensive package of speed management measures. This package will vary from one country to another and will need to take into account the current levels of road safety performance in each country.

8. For legal, liability and operational reasons, one country (Germany) has advised that it does not support the development and implementation of supportive ISA, whether voluntary or mandatory.

Most of the measures outlined in the study are likely to be applicable in all countries - and should be considered for both urban and rural areas.

However, it is suggested that countries without a long history of speed management begin by developing their strategies in urban areas where the greatest safety gains, especially to vulnerable road users, can be obtained quickly.

CHAPTER 1.

INTRODUCTION

This chapter sets out the background which led to the constitution of the OECD/ECMT working group on speed management. It presents the mandate of the Working Group, the reasons why a new report on speed management was necessary and the need for an integrated approach to speed. Finally, the structure and content of the report are described.

The dilemma caused by speed

Over the past five decades, society and individuals have benefited greatly from rapidly improving road systems. During the same period, the motor vehicle industry manufactured and sold motorised vehicles which were increasingly able to travel at higher speeds. On the one hand, high speed travel can lead to greater mobility and shorter journey times. On the other hand, higher vehicle speeds have adverse effects, principally in terms of road accidents and consequent death, injury, and material damage, but also in environmental terms (*e.g.* noise and exhaust emissions). As well, greater use of motor vehicles can have adverse effects on lifestyle and health (*e.g.* the cardiovascular health of the community) if it is associated with a reduction in walking and other exercise, as is often the case. At the same time, people living in mainly urban areas started to crave lower speeds and there was a growing demand to protect the environment, provide a better quality of life for the population, and also to ensure the safety of those living near roads: pedestrians, bicyclists, children, and people with reduced mobility.

A dilemma exists between speed where it is perceived as a sign of improved efficiency and a tool for progress, and the negative consequences of speeding which encompasses *excessive speeds* (*i.e.* high speeds which are above the legal speed limit) and *inappropriate* speeds (speed too fast for the prevailing conditions, but within the limits). This is not a new problem, but it has become increasingly prominent in a world where safety and sustainable development have gained more prominence and importance. Economic development requires growth in transport systems and improvements in transport services, and a natural response to this is to promote fewer barriers to speed in transport systems. However, in general, safety requires lower speeds, or at least the elimination of *excessive* speeds. At the same time there is a strong move in many jurisdictions towards limiting energy consumption and greenhouse gas emissions, and lower speeds can contribute directly to these goals.

The benefits and disadvantages of lower speeds are not perceived in the same manner by individuals and by the community as a whole. The societal consequences of road accidents are well known, and excessive speed is a major contributing factor. However, for an individual driver, the risk of being involved in an accident is relatively small and the driver therefore rarely experiences the worst safety consequences of excessive speed. The more journeys a driver completes successfully at a higher speed, the more the notion that high speeds are safe is reinforced. Similarly, the environmental effects of speeding are noticeable at an aggregate level (poor air quality), but are less obvious at individual level (possibly with the exception of fuel consumption). The issue of acceptable levels of speed to vulnerable road users and to residents arises where motor traffic shares the road with vulnerable road users, or passes close to people's homes, This contradiction between societal and individual consequences makes it a challenge to create sound speed management.

The Working Group

In 2004, the Joint OECD/ECMT Transport Research Centre launched a Working Group on Speed Management, in which traffic safety experts from 16 countries[1] participated.

In its mandate, the objectives of the Working Group were defined as follows:

- To assess the impact of speed on road safety, as well as traffic flow, environment and quality of life.

1. Australia, Canada, Czech Republic, Finland, France, Germany, Greece, Hungary, Iceland, Korea, the Netherlands, Norway, Portugal, Sweden, United Kingdom and the United States.

- To better understand the behaviour of drivers.
- To analyse and assess measures implemented to reduce speed: speed limits, infrastructure, signing and signalling, vehicle technologies, Intelligent Speed Adaptation; education and training, and enforcement.
- To define a framework with which to evaluate the overall impact of a set of measures on speed.

This report is the outcome of a two-year effort, during which the Group had several meetings and many exchanges. A number of elements presented in this report are drawn from a survey undertaken by the Group in 2004-05 which collected information on current speed management practices in OECD and ECMT countries.

Why a new report on speed?

Reflecting the importance of reduced speed for road safety, there have been a number of international studies and many national studies over an extended period focussed on how best to manage vehicle speeds in different settings.

In 2002, the OECD published *Safety on Roads: What's the Vision* (OECD, 2002) which identified the extent of speeding, its causes and general consequences and concluded: "The biggest problem with speed is that the majority of drivers do not consider speeding to be a serious road safety problem". In 2003, the OECD published a report on the impact of technologies on safety (OECD, 2003), which reviewed the positive and negative impacts of new technologies on safety, including on speed. The ECMT focussed on speed-related issues many years ago and Ministers have adopted many Resolutions, beginning with ones on the regulatory aspects of speed based on the analysis of speed limits and controls (ECMT Resolutions N^os^ 29 and 30, in 1974). However, it appeared from that time that speed was a broader issue that covered other areas, including social and economic aspects, which called for the development of speed moderation policies in the framework of road safety programmes. The ECMT report on "*Speed Moderation*", published in 1996, presented a range of recommended measures to moderate speed and achieve safer traffic and traffic calming.

The European Commission has also conducted two interesting and related projects: the MASTER project, which provides recommendations for speed management strategies and policies, and guidelines for the development of innovative speed management tools; and the GADGET project, which assesses the changes in driver behaviour resulting from the introduction of in-vehicle safety devices, visual modifications to the road environment, educational, training and legal measures, and safety campaigns.

Of course, many national transport administrations and road safety organisations have also undertaken studies in this area as they have attempted to deal with the extent of speeding in their countries and communities.

Why, then, publish a new report on speed?

There are a number of reasons. Over recent years, there has been a general increase in the social and political concerns related to speeding in many countries. Clearly, speeding has been increasingly recognised as one of the most important road safety issues. As well, it has become far more evident that the concerns do not relate exclusively to road safety, but also arise from general concerns for the environment (noise, emissions and pollution) and excessive energy consumption as well as social and lifestyle objectives.

Governments and their administrations therefore are being pressed to focus on the full range of adverse impacts, to identify measures that can effectively reduce speeding and to deal with the adverse consequences. Political leaders in some countries are seeking to implement programmes that include the most effective measures that can be taken. Speed and its consequences thus remain at the core of any travel policy and a subject of major concern.

This new report responds to these general concerns and the specific priorities set by the Joint OECD/ECMT Transport Research Committee, which agreed there should be a study of speed management undertaken by a Working Group drawn from OECD and ECMT countries. The aims in undertaking this project in this way included drawing on the expertise and benefiting from the research available in many member countries to outline desirable speed management approaches and effective measures that could be considered in dealing with speeding problems.

Public attitudes and demands regarding speed-related issues are evolving and are sometimes contradictory. While there is a growing demand for safer transport systems, there is also a desire in some quarters for a greater diversity in the speed limits, with lower speed limits in urban areas, and higher speed limits on major rural roads. There are also regular claims for higher speed limits on motorways in some regions or countries.

There are also new developments in the measures available to manage speed, and several technologies are currently being developed which may have an important impact on speed. Some of them are already in operation in the newest fleets (*e.g.* speed limiters, conventional cruise control and advanced cruise control); others, such as Intelligent Speed Adaptation, are undergoing trials and could be implemented in the near future.

Clearly, the approach to speed management is also evolving. In a number of countries, speed management is a central component of integrated road safety policies, such as “Sustainable Safety” (in The Netherlands) or “Vision Zero” (in Sweden).

In summary, there is a clear need for improved outcomes and significant changes have occurred in different fields related to speed during the past few years which can contribute to such outcomes. The experience gained by OECD and ECMT countries, and the results of new research, were therefore major factors supporting the preparation of this new report.

Audience for the report

The report is intended for a wide public audience and it is especially aimed at assisting policy makers, road safety professionals and researchers in addressing comprehensively the problems with speeding.

An integrated approach to speed management

Speed management can be defined as a set of measures to limit the negative effects of excessive and inappropriate speeds in the transport system.

Taking into consideration the extent of speeding in most countries, and the impacts of speeding, there is little doubt that effective speed management is needed. It is generally recognised that an integrated and comprehensive approach to speed management is likely to be one of the best ways to improve on the current situation.

Many countries are now developing their transport policy using integrated approaches, and a vast majority of countries apply measures, in one way or another, to manage motorised traffic speeds. These measures range from general speed limits to targeted police enforcement, publicity, infrastructure measures, and the use of new technologies along roads or in vehicles.

Road safety philosophy and speed management

Ideally, the measures adopted to deal with speeding should be based on a road safety philosophy which offers a desirable vision of the future.

Road safety philosophies generally express a long-term vision of an ideal road traffic system where accidents and serious personal injury are virtually eliminated. Road "accidents" are not considered accidental events that are the inevitable consequence of our demand for mobility; they are seen as events that can be prevented. The main elements of road safety philosophies reflect generally well known safety principles. People are fallible and make errors. Furthermore, people are physically vulnerable and can only withstand a limited amount of external forces. Therefore, road safety measures based on these philosophies and principles take account of these limitations and aim to develop a road system that:

- Minimises the chances of human error.
- Is forgiving of errors when they do occur.
- Prevents conflicts among road users with large differences in speed, mass and direction.

A road safety strategy that is based on these types of road safety principles almost automatically identifies speed as a major element of the safety problem, and speed management as a major area of interest.

The recent WHO world report on traffic injury prevention (WHO, 2004) sets out a number of guiding principles for road safety work which are based upon this line of thinking. It says, among other things, that:

> *"Road crash injury is largely preventable and predictable; it is a human-made problem amenable to rational analysis. Common driving errors and common pedestrian behaviour should not lead to death and serious injury – the traffic system should help users to cope with increasing demanding conditions. The vulnerability of the human body should be the limiting design parameter for the traffic system and speed management is central."*

In addition, the United Nations General Assembly, in its Resolution on *Improving global road safety*[2], has invited member States to take action on inappropriate and excessive speed.

Of course, a road safety philosophy is only useful if the general ideas are 'translated' into effective road safety measures. For this, the involvement, enthusiasm and commitment of stakeholders are essential. This is particularly true if many of the responsibilities for road safety are transferred to the regions and the municipalities, which is the case in many countries. A road safety philosophy helps to bring road safety higher on the political agenda and to set up an effective financial and organisational framework for road safety work. It also helps to stimulate rational discussion on the problem and to define and prioritise the areas for road safety action. It aims to motivate stakeholders at all levels to take action. Good monitoring of progress and feedback on the results to the partners

2. United Nations General Assembly, Document A/60/121 dated 1 August 2005.

involved are likely to create a stimulating and motivating atmosphere. And, last but not least, it is important, once a philosophy is adopted, to keep it alive amongst both policy makers and practitioners.

A road safety philosophy can help define a medium term road safety strategy, preferably structured by means of quantified road safety targets (see OECD, 2002). Once this is done, a corresponding short to medium-term action plan can be developed. With speed affecting both the accident risk and the severity of an accident, speed management can be expected to become one of the priority areas in a road safety strategy and the corresponding road safety action plan. A safe transport system requires a very strict speed policy, with (very) low speeds on some parts of the road network, especially in urban areas. Developments in this direction are taking place in several countries, such as The Netherlands and Sweden. Others are expected to follow soon.

Structure of the report

The report is composed of three main parts: Part I describes the problems caused by speed and the extent of speeding. Part II explains "how to address the problem of speeding". Finally Part III presents a general framework for a speed management policy. The main report is supplemented with two annexes: one presenting the major road safety philosophies; the other setting out the responses to the survey conducted in OECD/ECMT countries in 2004 (and updated in 2006).

Part I: The problem of speed (Chapters 2 to 3)

While recognising that speed has positive impacts on mobility, ***Chapter 2*** on ***the Effects of speed*** highlights the impacts that excessive or inappropriate speeds have on road safety, the environment, quality of life and other areas, and calls for a careful assessment of the overall impact of speed on the community as a whole.

Chapter 3 on ***the Extent of speeding and opinions about speed*** presents the general context of speeding. Excessive speed is a mass phenomenon. It concerns the vast majority of drivers, occurs on the entire road network, and is a problem common to all countries. The chapter illustrates the extent of speeding and presents some information on recent changes in drivers' opinions about speed.

Part II: How to address the problem of speeding (Chapters 4 to 10)

Chapter 4 on ***Road categorisation and road engineering*** describes infrastructure measures that can help manage speed and therefore form an important part of a speed management policy. It highlights the need to have sound classifications of the road network, and the importance of each road being self explaining, in the sense that drivers should be guided by the road and its environment to choose the appropriate speed. It reviews best practice measures for built-up and non built-up areas, and transition zones, and a range of technical measures which have proven their effectiveness. The chapter concludes by focusing on some key implementation issues which need to be addressed.

Chapter 5 on ***Setting speed limits*** outlines the basis for the assessment of appropriate speed limits. It reviews national speed limit regimes, including the underlying principles for defining general speed limits and local speed limits, and identifies the speed limits currently in force in OECD/ECMT countries. The chapter also identifies innovative approaches to the implementation of speed limits (*e.g.* variable and dynamic limits) and outlines policy considerations for setting speed limits.

Chapter 6 on ***Signs, signals and markings*** describes the various methods available to inform drivers about the speed limits, whether fixed or variable - and the role of road marking and signals, including moderating green waves. The chapter concludes with considerations related to the implementation of a consistent policy for signs, signals and markings.

Chapter 7 on ***the Influence of current vehicle technologies on speed*** reviews speed management systems that are either standard or optionally available in current motor vehicles. They can be considered conventional as, by contrast with intelligent transportation systems (ITS), they do not involve an exchange of information with other vehicles, infrastructure or communication networks and with other new technologies. The chapter discusses the various characteristics of a vehicle which influence speed, such as the engine power, vehicle seating position and equipment such as speedometers. It reviews current technologies to assist the driver in choosing the appropriate speed, including speed limiters, conventional cruise control, adaptive cruise control and speed monitoring systems.

Recognising that education, training and information are essential elements of speed management policy, and a prerequisite for other elements to succeed, ***Chapter 8*** on ***Education, training, information and incentives*** discusses the possibilities and limitations of education, training and information as a means to influence drivers' traffic behaviour in general and speed behaviour in particular. It reviews the education of children, young road users, and drivers as well as driver training, and the use of information and education aimed at licensed drivers.

Chapter 9 on ***Enforcement*** describes the general importance of enforcement, the mechanisms available for enforcement, and the general principles. It then zooms in on the different strategies for speed enforcement and considers the different instruments that are currently available and their effectiveness. It highlights the new dimensions of the enforcement approach that have opened up by the introduction of automatic control.

Chapter 10 on ***Future means for driver speed assistance and vehicle control*** highlights two of the major speed-related areas of current research and development across member countries. It focuses first on the different types of Intelligent Speed Adaptation (ISA) and then reviews other technological developments in member countries, including current research and development on longer term applications.

Part III: Framework for a speed management policy (chapters 11 and 12) and Summary of Recommendations (chapter 13)

The measures described in Chapters 4 to 10 are the components of a speed management policy. To achieve the best overall outcome, it is essential to build a consistent speed management policy, to establish a general action framework, to implement the appropriate measures and to undertake the necessary assessments of effectiveness.

Chapter 11 on ***Integrated speed management and main actors*** describes the objectives of speed management, the role of speed management in safe system mobility, the components of a speed management policy and how individual measures can be combined in the framework of a speed management policy package. The chapter concludes by describing the roles of the various actors involved and the actions they can take to achieve the desired speed management outcomes.

Chapter 12 *on* ***Knowledge transfer to developing countries*** highlights the specific needs of developing countries in terms of speed management and reviews areas where the experience of OECD/ECMT countries could be usefully transferred.

Finally, ***Chapter 13*** presents a summary of the recommendations of the report.

Annexes and appendix

Two annexes and an appendix complete the report:

- Annex A presents examples of national road safety strategies and philosophies, and the role of speed management.
- Annex B presents the responses to the survey undertaken by the Working group on experiences of OECD/ECMT countries with speed management.
- The appendix lists the experts who contributed to this report.

References and bibliography

At the end of each chapter, the reader will find the list of references which are cited in the chapter. A list of suggested further reading is included at the end of the report.

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PART I: THE PROBLEM OF SPEED

The first part of this report describes and explains why speed is such an important issue in our societies.

Chapter 2 describes the effects of speed. While recognising that speed can have positive impacts, for instance in significantly reducing travel time on interurban trips, the chapter highlights the adverse impacts that speed has on road safety, the environment and other areas. In this respect:

- Speed is the major road safety problem in many member countries and generally one of the top three problems across most member countries. Excessive speed (above the speed limit) or inappropriate speed (inappropriate for the prevailing conditions) are contributing factors in about one third of accidents and aggravating factors in all accidents.

- Speed has significant impacts on the environment, as the level of exhaust emissions (mainly carbon monoxide, nitrogen oxides, hydrocarbons and particulate matters), fuel consumption and noise emitted by vehicles are closely related to vehicle speed.

- Speed has a very important impact on the quality of life in urban areas, where fast moving vehicles can interfere with the quality of life of urban residents and impact on the safe mobility of pedestrians, cyclists and other vulnerable road users.

Chapter 3 illustrates the extent of the problem. It highlights the fact that speeding is a mass phenomenon involving all types of drivers and all types of vehicles on all types of roads. It identifies some factors that explain this behaviour by road users, based on recent surveys undertaken, notably in Europe and the United States.

The second part of the report describes the various means available to change driver behaviour and reduce vehicle speeds.

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CHAPTER 2.

EFFECTS OF SPEED

This chapter focuses on the effects of speed and the problems caused by speed. While recognising that speed has positive impacts on mobility, it highlights the adverse impacts that excessive or inappropriate speeds have on road safety, the environment, the quality of life and other areas, and calls for a careful assessment of the overall impact of speed for the community as a whole.

2.1. Introduction

The effects of speed – both positive and negative – make speed a prime target for policy action. Speed management policies may have a number of aims but, when accident prevention and casualty reduction are the prime objectives, they are often seen to be in conflict with other goals valued by individuals and society, such as rapid journey times and optimal use of available traffic capacity. Other objectives are synergistic, such as the aim of reducing levels of speed to minimise fuel consumption, emissions and noise. In each case, policy makers need to take into account the acceptability of specified levels of speed to all types of road users. All these effects, both positive and negative, should therefore be assessed comprehensively in developing appropriate speed management policies.

This chapter introduces the benefits and identifies the various adverse impacts of speed in a range of areas of interest.

2.2. Benefits of speed

Speed in undertaking activities is generally perceived by society as an asset. Rapidity is a property which is generally highly prized, with everything expected to be done faster: production, processing, exchanges, *etc*. In the field of transport, speed is often also seen as a "positive". Technological advances have made it possible to travel faster by car, train (*e.g.* high speed train) and plane, and by doing so to significantly decrease travel times for passenger travel and for goods movement.

Faster travel is also seen as offering greater mobility which is highly regarded by both individuals and companies. For individuals, faster travel makes it possible to do more *e.g.* visit friends and relatives more often, go farther on vacation, live further from work places (where accommodation may be cheaper and more pleasant), and live in locations where high travel speeds enable access to a wider range of job opportunites. For businesses, faster transport allows and supports just-in-time production, increased trade with customers from other regions/countries, and greater efficiency.

Increased speed and reduced travel times are of course often critically important for many essential services *e.g.* for emergency vehicles. Ambulances and fire vehicles can arrive faster at the scene of an incident. Increased speed is also an important advantage for public transport vehicles, such as inter-urban coaches and intra-city bus services.

Speed may also be a source of pleasure for the driver. Many drivers enjoy driving, and speed affords a sense of freedom and possibly some excitement.

Speed in road transport is therefore linked to many advances in society and perceptions of improvements in individual and community welfare. However, the perceptions may be different from reality. While faster travel speeds allow shorter travel times and are often perceived as producing significant travel time savings, for road traffic, the time gains are usually more significant over longer distances (*e.g.* on interurban travel) than on shorter distances around cities where traffic is often delayed at intersections and by congestion.

2.3. Adverse impacts of speed

Excessive or inappropriate speed on the roads has a number of significant impacts that need careful consideration. Speeds that are too high can have strong adverse effects, principally in terms of road accidents and consequent death, injury, and material damage, but also in contributing to significant increases in noise and exhaust emissions.

The adverse impacts of speed – and more particularly excessive or inappropriate speed – must be well understood to allow the best measures to be identified and introduced. Assessments need to take into account the advantages and disadvantages to society as a whole as well as the interests of individual road users. It is important to assess the impacts carefully so that appropriate levels of protection can be assured and any required trade-offs can be made between the other competing and complementary objectives involved, allowing the development of a speed management policy that will deliver the best possible outcomes for the population as a whole.

2.3.1. Effects of speed on road safety

Speed as a contributing factor to accidents

Based on a survey of Road Safety Performance in member countries undertaken by the Joint OECD/ECMT Transport Research Centre in 2005 (OECD, 2006), excessive and inappropriate speed is the number one road safety problem in many countries, often contributing to as much as one third of fatal accidents and an aggravating factor in most accidents.

In general, the number and severity of road traffic accidents rise as speed increases. There are many contributing factors.

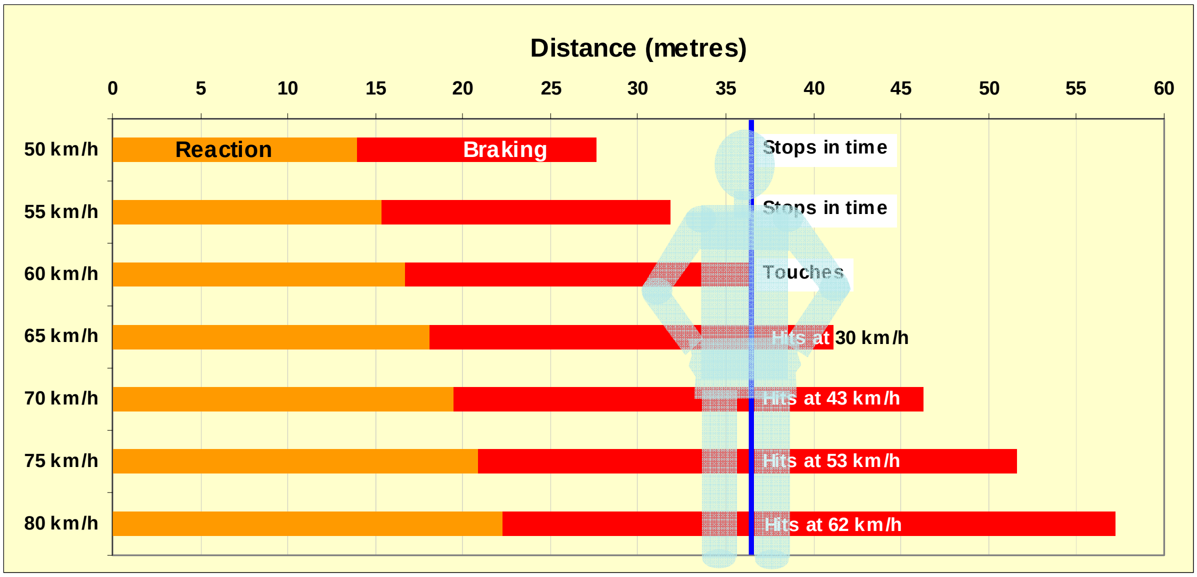
Firstly, high speeds reduce the time people have available to process information, to decide whether or not to react and, finally, to execute an action. This means the distance covered during normal reaction time periods increases with an increase in speed.

Second, as braking distance is proportional to the square of the speed (v^2), the distance between starting to brake and coming to a complete standstill also increases greatly with increasing speed. The time needed is composed of two elements: the reaction time of the driver (approximately 1 second in standard conditions)[1] and the braking time.

Third, the possibility of avoiding collisions reduces as speed increases. As an example, as shown in Figures 2.1, with a speed of 80 km/h on a dry road, it takes around 22 metres (the distance travelled during a reaction time of approximately 1 second) to react to an event, and a total of 57 meters to come to a standstill. If a child runs onto the road 36 meters ahead, the driver would most likely kill the child if driving at 70 km/h or more, hurt the child if driving at 60 km/h and avoid hitting the child if driving at 50 km/h. However, if the child runs out on to the road 15 metres ahead of the driver, the probability is that the child would be fatally injured at 50 km/h and all higher speeds.

1. The reaction time varies from one person to another. 1 second is the minimum reaction time. In some studies, the reaction time is estimated to be around 1.5 second.

Figure 2.1. **Stopping distance at different speeds (including reaction time of around 1 second)**



Source: adapted from ATSB.

Finally, the stopping distance also depends on the type of pavement (its friction coefficient) and the condition of the road. Stopping distances are much higher on wet roads than on dry roads. As an example, at 60 km/h a driver needs around 46 metres to come to a standstill on a wet road, an additional 10 metres over the distance required when stopping from the same speed on a dry road. In other words, at this speed, 60 km/h, the stopping distance required on a wet road is over 25% greater than on a dry road. Putting this another way, the stopping distance when driving at 60 km/h on a wet road is similar to the stopping distance when driving at 70 km/hr on a dry road.

Effects of speed on the frequency of accidents

Broadly speaking, each 1 km/h reduction in average speed leads to a 2-3% reduction in injury accidents (ETSC 1995 based on Finch *et al* 1994) (see also figure 2.4 on the Power Model). This is a modelling estimate only, it does not apply to every individual road. In real life, there is a range of effects, with the largest decreases being found on urban roads and the smallest on motorways.

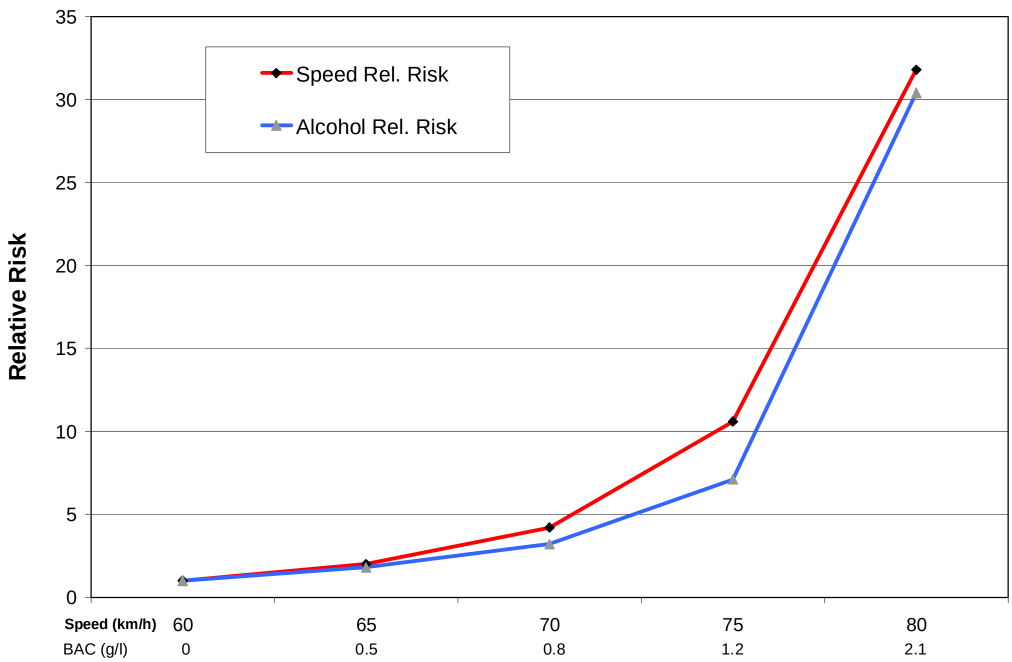
The design and functional characteristics of the road largely affect the precise relationship between speed and accident frequency (see also the section below on impact of speed on severity of accidents). This depends, for example, on the number and type of intersections; or the presence of pedestrians, cyclists or agricultural vehicles. In more complex traffic situations, the accident risk is higher and the effect of speed larger. Motorways, for instance, are low complexity roads with relatively lower rates of accidents, while an urban arterial road is more complex.

Accident risk depends on the country concerned and type of road in that country. In most industrialised countries, about 60% of fatal accidents occur on rural roads. Single, run-off the road accidents constitute a growing concern, and inappropriate speed is the source of most of these accidents. The principal victims of inappropriate speed in urban areas are vulnerable road users (pedestrians, cyclists, motorcyclists). Speed and weight differentials are the main factors.

In South Australia, Kloeden *et al* (1997) compared the risk of increased speed on accident occurrence on urban roads with a 60 km/h speed limit to the risk associated with higher levels of blood alcohol content (BAC). Figure 2.2 shows that the relative risk of accident rises rapidly at speeds above 70 km/h (*i.e.* 10km/h above the speed limit) and is similar to that associated with driving with blood alcohol levels of 0.8 g/l. As well, the graph shows an increase in accident risk with increasing speed that is remarkably similar to the increase in accident risk associated with driving with increasing levels of blood alcohol.

Figure 2.2. **Relative risks of casualty accident involvement associated with speed and with blood alcohol content (BAC) on urban roads with a 60 km/h speed limit**

Risk = 1 for BAC = 0.0 g/l and for speed = 60 km/h



Source: adapted from Patterson *et al,* 2000, based on Kloeden, et al 1997.

Impact of heterogeneity and dispersion of speed on accidents

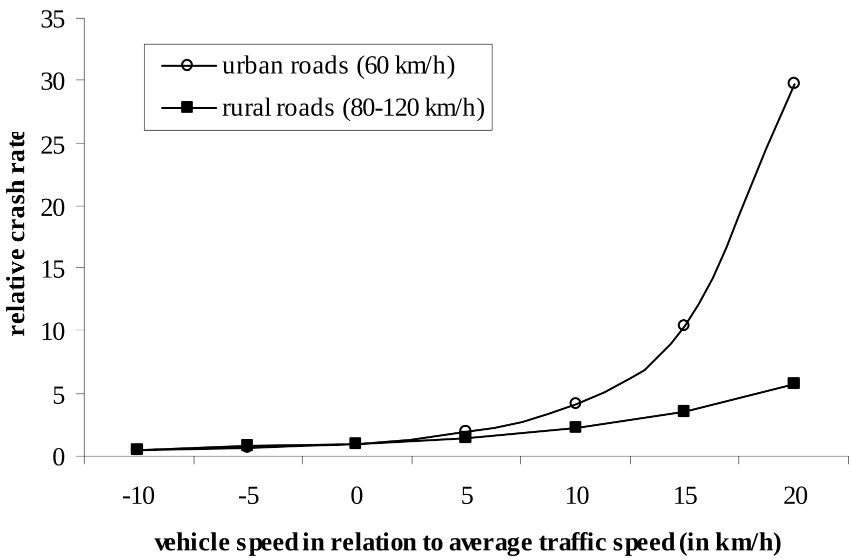
Speed differentials between the various road users have a significant impact on accident rate. This is particularly important in urban areas, where there is always a mix of motorised road users, some who drive fast, and motorised traffic is mixed with other, vulnerable road users, such as cyclists and pedestrians, who move more slowly. It is equally important on motorways on steep hills (both up and down hills), where passenger cars and trucks may have significant speed differentials.

Heterogeneous speeds between vehicles lead logically to more overtaking and a higher level of accident risk. Speed dispersion (*i.e.* variation of speeds in traffic flow) is strongly related to fatality rates, in particular on interstate highways, rural roads and urban arterial roads. In most cases, increased travel speed leads to an increase in dispersion. In some cases, though, it was found that increased average speed leads to a narrowing of speed dispersion (TRB, 1998).

Research on urban roads indicates that the higher the proportion of drivers who exceed the speed limit, the more accidents occur. Individuals driving at more than 10-15% above the average speed of the traffic around them are much more likely to be involved in an accident (Maycock *et al* 1998, Quimby *et al* 1999a and b). Accident frequency rises by 10-15% if the average speed of these motorists increases by 1 km/h (Taylor *et al* 2000). Kloeden *et al* (2002) also found a higher accident risk for fast drivers, particularly in urban areas (see Figure 2.3.).

Figure 2.3. **Relative injury accident rate on urban roads and rural roads for vehicles going faster and slower than average speed**

0 corresponds to the average speed.



Source: Kloeden *et al.,* 1997, 2001 and 2002.

Note: Exposure was taken into account in the studies by Kloeden, as they were based on case-control studies.

Figure 2.3 shows that, compared to driving at the average speed, driving at a slower speed does not increase the risk. However, some other studies have found that for non-injury accidents, there is similar accident risk for the "slowest drivers" and "fastest drivers" (West and Dunn, 1971).

It is interesting, in this respect, to focus on the overall accident risk of older drivers, who tend to drive more slowly than the rest of the traffic flow. By adjusting their driving to their capabilities, they generally maintain, or minimise, their risk level. Given their slower information processing capabilities, it would be inadvisable to recommend that these people drive faster so as to reduce speed disparities in the traffic stream. Removing older drivers from high-speed roads may actually be detrimental to safety. They generally restrict their driving to safer roads, and their accident involvement may actually increase on other roads with higher accident risk (TRB, 1998). It is in addition important to maintain safe mobility for the elderly (OECD, 2003).

To sum up, it is important to decrease both the speed level and the speed differential between vehicles in a traffic stream. Importantly, reducing the speed of all drivers, and in particular the speed of the fastest drivers, is likely to bring significant accident-reducing benefits. Where the speed differential between the slowest vehicles and the fastest vehicles is very large (downhill or uphill on a motorway), a dedicated lane (in both directions) for the slow vehicles is often recommended.

Effects of speed on severity of accidents

Even when speeding is not the decisive cause of an accident, the severity of injury is highly correlated with the vehicle speed at the moment of impact. The effects follow the rules of physics regarding the change in kinetic energy that is released in an accident. The energy released and absorbed in an accident is linked to the impact speed in an accident, and most of the kinetic energy is absorbed by the lighter crash “opponent” – often the vulnerable road user.

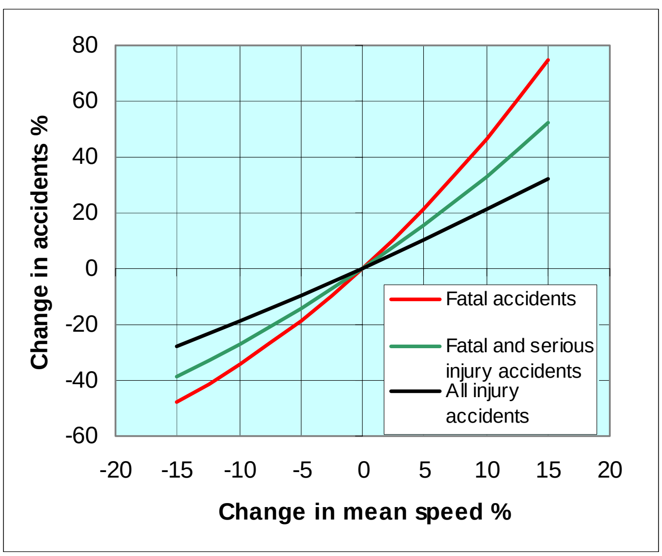
The likelihood of being seriously injured in a collision rises significantly even with minor changes in impact speed.

The relationship between serious injury accidents, fatal accidents and speed has been modelled by Nilsson and is commonly illustrated by the “Power Model” (see figure 2.4). According to this model – which can be applied to the common range of speeds – serious injury accidents are related to the third power of the speed; and for fatal accidents, the fourth power of the speed (Andersson *et al*., 1997, Nilsson 2004, Elvik *et al*, 2004) as shown in Figure 2.4.

Based on the Power Model, a 5% increase in mean speed leads to approximately a 10% increase in all injury accidents and a 20% increase in fatal accidents. Similarly, for a 5 % decrease in mean speed there are typically 10% fewer injury accidents and 20% fewer fatal accidents[2].

The effect on the number of fatalities is higher than the effect on the number of fatal accidents and corresponds, on average, to the power of 4.5 - as presented by Elvik *et al.,* (2004).

Figure 2.4. **The power model: relationship between change in mean speed and accidents**



Source: Nilsson (2004).

2. These are approximate figures, easy to remember. Exact figures found by Nilsson are the following: a 10% increase in mean speed leads to a 21 % increase in all injury accidents, a 33% increase in fatal and severe injury accidents and a 46% increase in fatal accidents. For a 10% decrease in mean speed, there are 19% fewer injury accidents, 27% fewer fatal and severe accidents and 34% fewer fatal accidents. However, it should be kept in mind that any model is a simplified representation of reality. The Nilsson model while founded on a sound scientific base, can not take into account all the characteristics of the road environment. The actual effects depend on the exact road traffic and characteristics. For example, the effect is considerably larger on urban roads as compared to motorways.

The situation is quite different according to the type of road and the reference speeds on these roads. Based on the Power model, Aarts and van Schagen (2006) have developed Table 2.1, which shows the impact of a 1 km/h change on the severity of accidents for roads with different reference speeds[3]. The greater impact of a reduction in speed is logically to be expected for the slower roads, typically in urban areas.

Table 2.1. **Application of the Power model for different reference speeds**

Percentage change in accidents for 1 km/h change in average speeds						
Accident severity	**Reference speed (in km/h)**					
	50	70	80	90	100	120
Injury accidents (%)	4.0	2.9	2.5	2.2	2.0	1.7
Injury and fatal accidents (%)	6.1	4.3	3.8	3.4	3.0	2.5
Fatal accidents (%)	8.2	5.9	5.1	4.5	4.1	3.3

Source: Aarts and van Schagen (2006).

The consequences of accidents also depend on the type of accidents and the type of road users involved. Mackay (1997) undertook a comprehensive review of the biomechanics of impacts in road accidents, which indicates that there is no simple relationship between impact severity and the severity of injuries sustained by road users.

Pedestrians, cyclists and moped riders for example have a high risk of severe injury when motor vehicles collide with them, as they are completely unprotected: no steel framework, no seatbelts, and no airbags to absorb part of the energy.

The probability of a pedestrian being killed in a car accident increases with the impact speed. Results from on-the-scene investigations of collisions involving pedestrians and cars show that 90% of pedestrians survive being hit by a car at speeds of 30 km/h; whereas only 20% survive at speeds of 50 km/h (see figure 2.5). The figure also shows that the impact speed at which a pedestrian has a 50 % chance of surviving a collision is around 40-45 km/h. Other studies[4] have found slightly higher figures — partly explained by the fact that minor injury accidents involving pedestrians are often not reported, thus creating a statistical bias with the available data — however there is a clear indication that a lower impact speed results in less severity (INRETS, 2005). In addition, elderly pedestrians are more likely to sustain non-minor and fatal injuries than younger people in the same impact conditions due to their greater physical frailty.

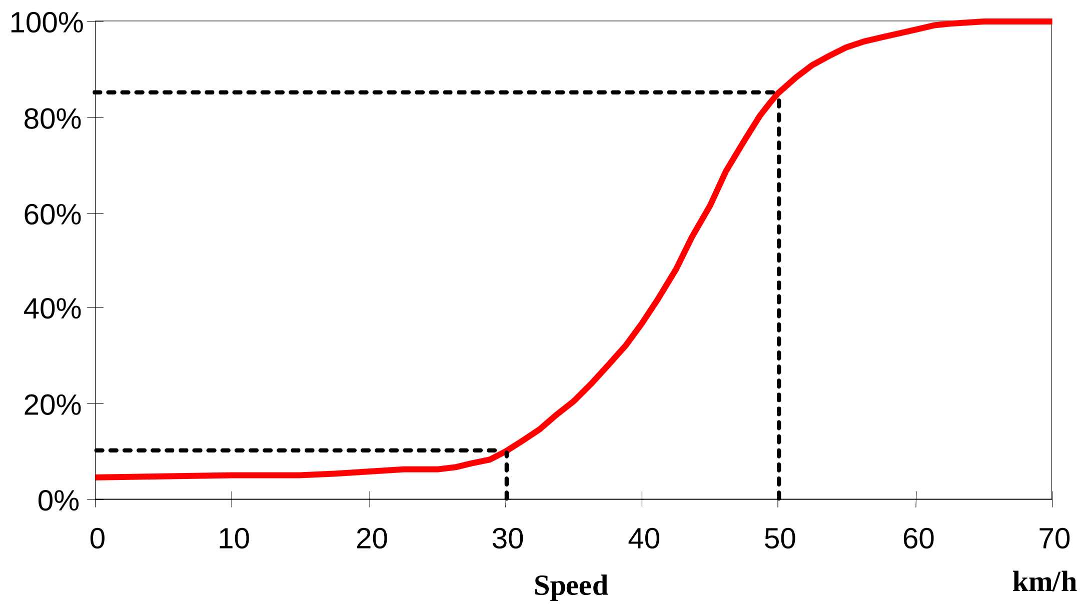
A well-protected occupant of a modern car would, in most cases, not be injured at all at a similar impact speed in a frontal accident. According to WHO (2004), wearing seatbelts in well –designed cars can provide protection to a maximum of 70 km/h in frontal impacts and 50 km/h in side impacts (excluding impacts with obstacles such as trees or poles for which the protection is only effective for

3. Reference speed is the "original speed" driven on a road before a change.

4. (Davies, 2001) found that the impact speed at which 50% of pedestrians could survive the collision is 70-75 km/h (for the 15-59 years old) and 50 km/h for the +60 and the less than 15 years old. (Pasanen, 1992) found an impact speed of 55 km/h.

lower maximum speeds). If, on the other hand, the car is struck from the rear, whiplash injuries leading to long-term impairment may occur even at impact speeds of 15-20 km/h (Elvik *et al* 2004).

Figure2.5. **Probability of fatal injury for a pedestrian colliding with a vehicle**



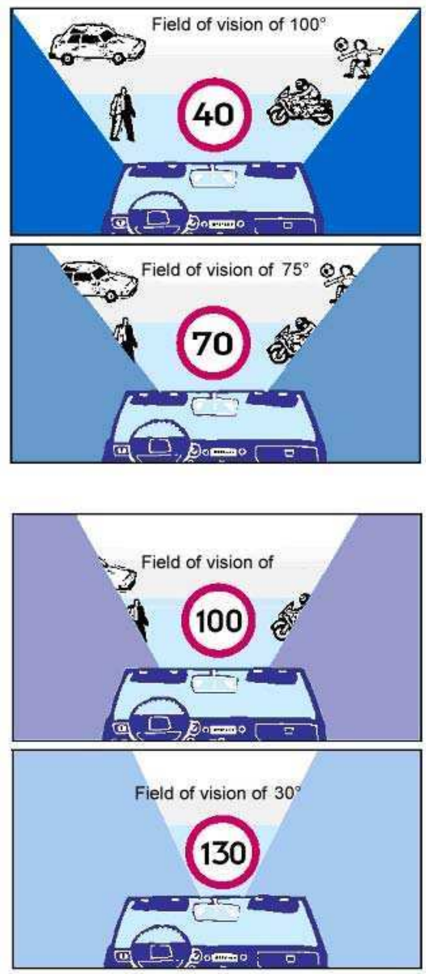
Source: Interdisciplinary Working Group for Accident Mechanics (1986); Walz *et al.* (1983) and Swedish Ministry of Transport (2002).

In addition to the increased risk to vulnerable road users, there is increased risk of serious injury to occupants of light vehicles in collisions with a heavier vehicle (Broughton, 2005). This is because the energy that is released in the collision is absorbed mainly by the lighter vehicle and even small differences in mass can make a significant difference. Current trends in vehicle design are leading to many larger and heavier cars, while light vehicles are continuing to be produced, thus increasing the difference in mass of the new vehicles being manufactured. A mass difference of a factor of 3 is not an exception for vehicles on the road, especially between older and newer cars. The difference in mass between a car and a heavy goods vehicle is even larger and can easily be 20 times greater.

Effects of speed on the visual field

As shown in Figure 2.6, the visual field of the driver is reduced when the speed increases. At 40 km/h, the driver has a field of vision covering 100°, which allows obstacles on the roadside, or other potential hazards, to be seen. At 130 km/h, the field of vision covers around 30°, which reduces considerably the capability of the driver to assess potential danger.

Figure 2.6. **Impact of speed on the field of vision**



Source: French Ministry of Transport.

Impact of congestion on accident frequency

There have been few studies of the relationship between congestion and accident risk. Congestion leads to decreased speeds and as such has a positive impact on the severity of accidents. At the same, some studies have shown that congested conditions led to more accidents (Brownfield *et al.,* 2003).

2.3.2. Environmental effects

Effect of speed on exhaust emissions

Emissions from road vehicles contain a variety of pollutants which are produced in different quantities at different speeds. The major pollutants are:

- carbon monoxide (CO);
- hydrocarbons (HC);
- oxides of nitrogen (NO_x); and
- particulates (in some counties referred to as particulate matter - PM).

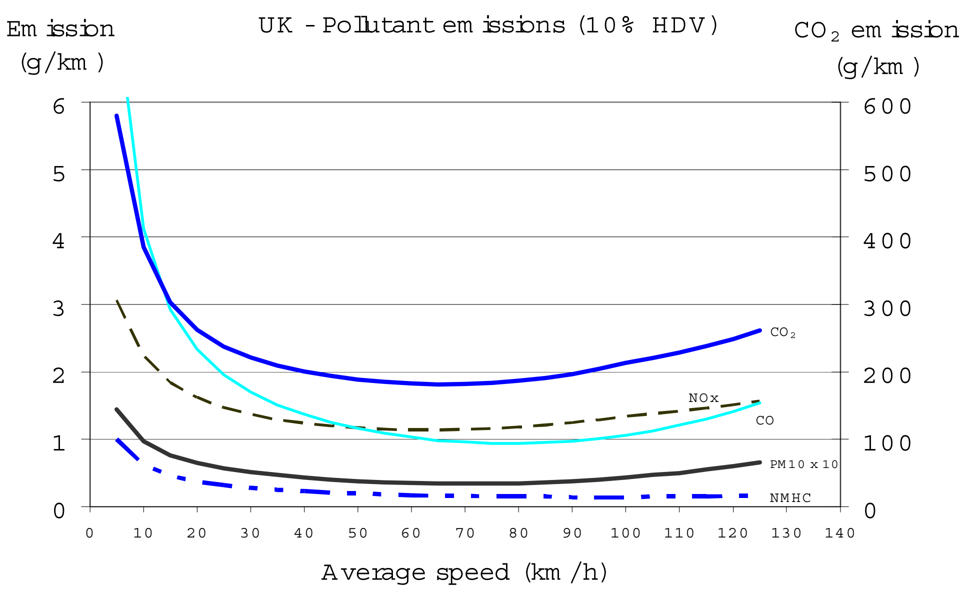
The pollutant production processes are complex, and vary within vehicles as well as across vehicle classifications and engine technologies. Oxides of nitrogen (NOx) are produced particularly at high engine operating temperatures (*e.g.* steady high speed driving) and a reduction in speed leads to a significant reduction in these emissions. The effects of speed reduction strategies on carbon monoxide and hydrocarbons are less clear. Hydrocarbons (HC) emissions reduce with lower speed, whilst carbon monoxide (CO) and particulates (PM) have the lowest emission levels at medium speeds.

Carbon dioxide (CO_2) is a greenhouse gas associated with global warming, but the extent of its impact is currently a matter of considerable debate. Carbon dioxide is produced in proportion to fuel consumption.

The optimum speed, *i.e.* the speed at which emissions are minimised, varies according to the type of emission. Typically, pollutant emissions are optimised for constant speeds of 40-90 km/h (figure 2.7). According to Japanese studies, the optimum speed would fall in a smaller range for trucks and buses, around 50-70 km/h (ITS Handbook, 2005-2006, Highway Industry Development Organisation (2005)). It should also be noted that in steady driving conditions, CO and CO_2 emissions in terms of g/km travelled are highest at very low travel speeds (15 km/h or less).

It is notable that modern vehicles, using the latest vehicles technologies, have much lower levels of local pollutants than older vehicles and that emissions from these modern vehicles are in fact much more sensitive to acceleration than to average speed.

Figure 2.7. **Gaseous emissions as a function of speed**
United Kingdom (2005)



Source: UK Department for Transport

Driving style is therefore an important factor, since rapid acceleration increases fuel consumption and therefore emissions significantly. Cold starts and acceleration can also increase exhaust emissions disproportionately because the engine and catalytic converter are cold. De Vlieger (1997) tested the emissions of seven cars in Belgium under normal and aggressive driving conditions. Aggressive driving is described as sudden acceleration and heavy braking. Normal driving had moderate acceleration and braking. Table 2.2 shows that emissions from aggressive driving are generally higher than those in normal driving.

Table 2.2. **Average measured emission factors in g/km of three-way catalyst cars under normal and aggressive driving conditions.**

Pollutant g/km	Road Type	Normal Driving	Aggressive driving
CO	City cold start	15.1 ± 4.5	27.9 ± 8.6
	City hot start	7.2 ± 5.0	14.8 ± 6.8
	Rural road	4.5 ± 3.4	11.8 ± 6.9
HC	City cold start	2.2 ± 1.1	3.7 ± 1.2
	City hot start	1.1 ± 1.0	0.93 ± 0.65
	Rural road	0.54 ± 0.50	0.63 ± 0.38
NO_x	City cold start	0.32 ± 0.20	0.54 ± 0.21
	City hot start	0.25 ± 0.20	0.34 ± 0.18
	Rural road	0.18 ± 0.15	0.21 ± 0.13

Source: de Vlieger, 1997.

Effect of speed on fuel consumption

In non-congested conditions, fuel consumption – and as a consequence resource cost – increases with increasing speed. In such conditions, reducing speed from high levels leads to reduced fuel consumption and lower resource costs, and contributes to a less rapid depletion of the reserves of non renewable resources. As an example, at constant speed, driving at 90 km/h in comparison to 110 km/h leads to around a 23% saving in fuel consumption. However, at lower speed levels, reduced speeds do not necessarily lead to reduced fuel consumption. At speeds below around 20 km/h, for example, fuel consumption increases significantly.

Driving style also has an important impact on fuel consumption. An aggressive driving style usually leads to about a 30% increase in fuel consumption.

Impacts of vehicle speed on ozone

Ozone is not emitted directly by motor vehicles. It is formed in the atmosphere through a complex set of chemical reactions involving hydrocarbons, oxides of nitrogen, and sunlight. Vehicles emit a high proportion of total hydrocarbons and nitrogen oxides, especially in urban areas. In hot periods, vehicle emissions associated with sunlight and heat lead to a sharp increase in ozone levels.

Ozone has severe effects on health, and older people and children are the most sensitive to high levels of ozone which can cause severe breathing problems. Ozone levels are not necessarily the highest at locations where it is formed, as wind moves ozone. Ozone pollution from urban areas is often transported to surrounding areas and can affect rural regions.

To reduce ozone levels during the summer months, a number of national or local governments set lower speed limits when pollution peaks are expected.

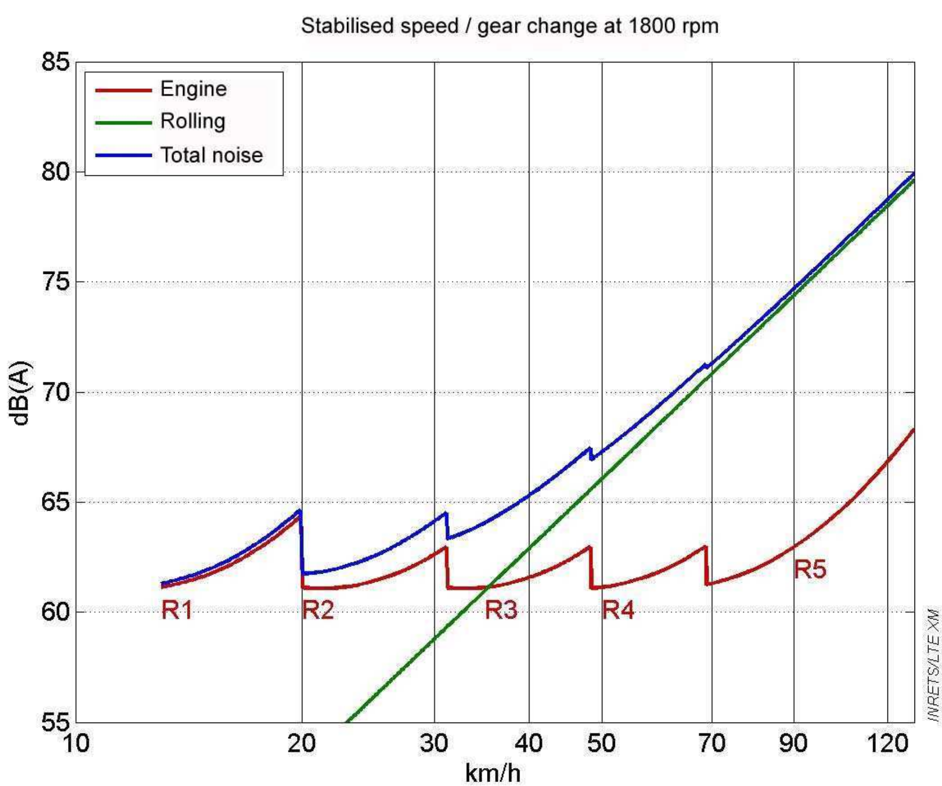
Effect of speed on noise

Speed has a considerable effect on the exterior noise that a vehicle emits. The relationship is monotonic, with a lower speed always resulting in a lower noise level, although other factors, such as the frequency of accelerations, can in some cases be more important than the mean speed.

Traffic noise arises from two main sources: the power units of vehicles and tyre-road interaction (see figure 2.8). Noise from the latter dominates at higher speeds — above the range 20-40 km/h for new cars, and above 30-60 km/h for new lorries —because tyre-road noise increases strongly with speed, typically by 12 dB(A) for a doubling of speed . For older vehicles the speeds above which tyre-road noise dominates are about 10 km/h higher, because power unit noise has been progressively reduced due to developments in technology in newer vehicles.

Effects of acceleration and deceleration on noise are typically modest at speeds over 50km/h, but higher at speeds lower than this. This has implications for the use of intermittent speed-reducing devices, such as road humps or chicanes. Specially textured surfaces and surface wetness can also affect the level of noise.

Figure 2.8. **Engine noise and rolling noise as a function of speed**



Source: INRETS.

2.3.3. The effects of speed on quality of life

Traffic speed, actual and perceived, affects the assessments people make of the quality of life. The effects are difficult to quantify but the adverse social costs are borne mainly by those outside of moving vehicles. These will differ according to the type of area, the local circumstances and the local environment. Injuries and noise are easiest to identify and measure, but it is harder to quantify the effects that the fear of fast moving vehicles has in discouraging people from walking and cycling, or in limiting their enjoyment of, or ability to reach, the facilities and services in their vicinity.

Fast traffic contributes to the severance of communities, and disproportionately affects those who find it difficult to cross busy roads, especially older people and children. In the worst cases, such severance can increase inequalities and lead to social exclusion within communities by making it more difficult to form support networks and, for those without cars, to get to necessary facilities, such as shops, schools and medical services (UK Department of Health 1998, UK Health Education Authority 1998). Pollution levels and general public health are worse in inner cities and child road casualty rates in poorer neighbourhoods are higher than average (Christie 1995).

Physical activity is important in reducing heart disease and strokes (UK Department of Health, 1999), and if the perceived danger from fast moving traffic dissuades some people from walking and cycling, it could affect their health and general fitness. The fear of danger from traffic is one of the important reasons given for accompanying children, often by car. Walking to school needs to be encouraged to become a more attractive and feasible option which would have potential benefits for children's health now and in the longer term.

Gains from changes in speed for one group of people often mean losses to some other group. Increased speeds mean greater losses to communities and individuals outside the car, and slower speeds mean longer travel times. From society’s point of view such distribution and equity impacts can be as important as overall efficiency of the network, sometimes even more important. It is the distribution of the positive and the negative impacts of speed that affects people’s quality of life.

2.3.4. Impacts of speed on journey times

The time taken for a journey is clearly related to speed. Higher speeds offer the potential of travel time savings which may allow individual road users to do more with their time and allow greater productivity for commercial operations. However, while on inter-urban trips, higher speed has a noticeable impact on time savings, the actual time savings associated with higher speeds are often less certain in urban areas.

Studies illustrating the impact of travel speed on journey time have been undertaken in a number of cities, including Toulouse (France). In Toulouse, travel times were measured at different times of the day along a 7.6 km route containing 28 traffic lights. Two travel speeds were tested:

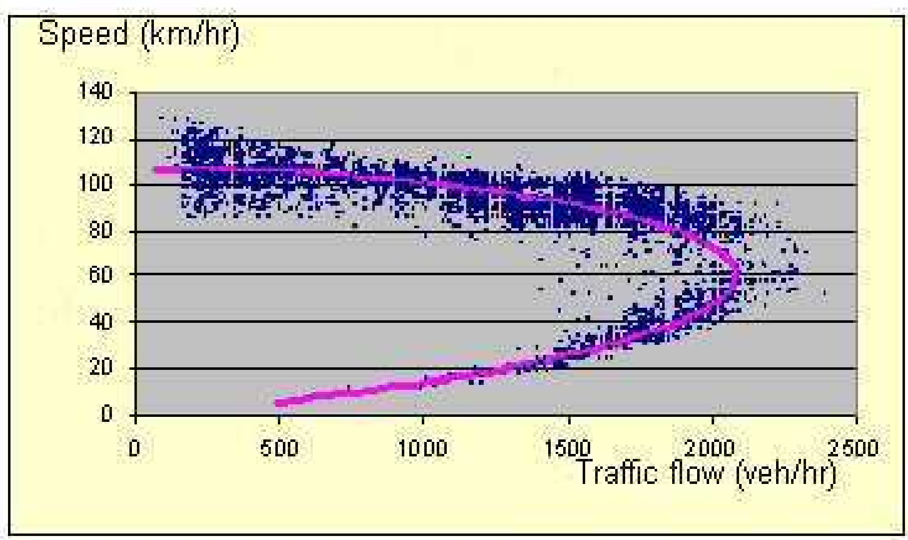
- A “fast” vehicle, respecting the speed limit of 50 km/h.
- A “slow” vehicle, not going faster than 30 km/h.

The average travel speed of the fast vehicle was 19.1 km/h, while that of the slow vehicle was 15.9 km/h. The study concluded that a reduction by 40% of the maximum authorised speed only led to a 20% increase in the travel time, due in part to the greater number of times the slower vehicle stopped at traffic lights. In this study, the average travel times that resulted were around 24 minutes for the fast vehicles and around 29 minutes for the slow vehicles (ZELT, 2004).

In all transport economic studies, consideration is given to travel time and generally travel time savings are taken into account. However, one area where there is controversy is small travel time savings. This is an on-going debate over how meaningful and realistic it is to aggregate very small time costs or savings, which often amount to only a small number of seconds per vehicle over a link, over thousands or millions of trips which could produce large estimates of travel time costs or savings. In other words, how large does the time cost or saving have to be before it is perceived by vehicle occupants and before it would actually be useful and valued highly? Practice in the valuation of such changes differs in this respect among jurisdictions. Some jurisdictions aggregate all changes in time, however small, and value the total, whilst others disregard changes smaller than a certain threshold (*e.g.* 5 minutes).

It is sometimes argued that reducing vehicle speeds will reduce the throughput of a road. However, it is worth highlighting that for urban motorways, throughput is maximised for travel speeds of around 50-80 km/h. Figure 2.9 illustrates the relationship between traffic flow and speed for a 2x2-lane urban motorway in France. It shows that speeds reduce as traffic increases until traffic reaches levels where traffic flows become unstable. Maximum traffic throughput occurs at travel speeds around 60-70 km/h.

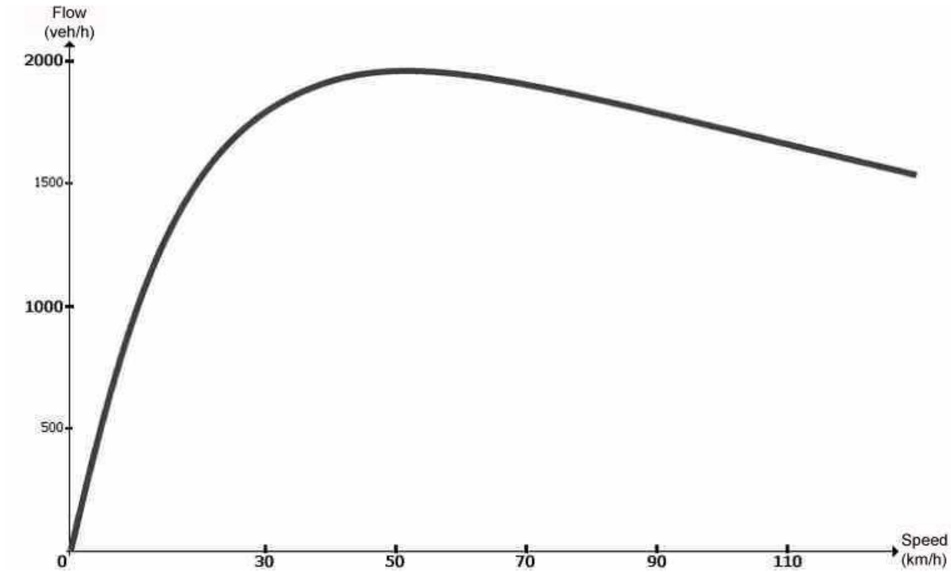
Figure 2.9. **Traffic flow per lane as a function of travel speed for an urban motorway (2x2 lanes)**



Source: NSC (France).

Other studies have shown that, in built-up areas, reducing the average speed from 50 km/h to 30 km/h does not cause a very significant decrease in traffic flow capacity (see figure 2.10).

Figure 2.10. **Traffic flow as a function on speed on an urban road**



Source: Sehier.

The total travel time of a journey is an important element for most road users; however the predictability and reliability of the journey may often be even more important. A more homogeneous distribution of speeds leads to better traffic flows and thus to more predictable journey times.

While this section has focussed on only certain aspects, the available evidence suggests that speed management is not necessarily incompatible with mobility and economic need. As well such factors need to be considered in the context of other policy objectives including reduced traffic fatalities and improved environmental outcomes. It is important to recall that the effects of speed in reducing overall travel time are generally overestimated, especially in urban areas.

2.4. Effects at network level – Speed and urban sprawl

National or regional changes in speed management policy may permanently change the accessibility of locations in relation to each other, which in turn may lead to spatial socio-economic effects occurring in the long run. For example, greater speed of travel allows a household to relocate farther from its workplace to areas where the household may be able to obtain a larger, or otherwise more attractive, dwelling for costs similar to those prior to the move. Although there may be substantial costs involved, there is plenty of evidence of some people making changes over time in the other direction, *e.g.* moving to be closer to work locations. Another fairly common trend amongst some companies in centralised locations is to relocate to areas closer to the residential locations of their workforces.

According to the conjecture of Zahavi (Zahavi *et al.,* 1980), on average, journey time remains constant at between 60 and 90 minutes per day, depending on the size of the urban area. This means that if travel speed increases (for instance following the creation of new infrastructure), there is not a reduction in journey time (or only in the period that follows immediately the opening of the new infrastructure, and it is only marginal), but, rather, the opposite in the longer term, *i.e.* an enlargement of the area covered by daily trips. Whilst this enlargement has economic benefits through the production of wealth through more activity (Poulit, 2005), it also contributes to urban sprawl with its concomitant disadvantages (ECMT, 2005). The decision to move farther from the workplace has a direct effect on the amount of kilometres travelled. Companies may naturally make similar kinds of decisions.

Some people wonder whether it would be possible, by reducing the authorised speeds, in particular on "high" speed infrastructure, to limit urban sprawl. However, the effects of reducing speeds in this way and the possibility of such a reverse shift are not proven, and nothing (to the contrary) can show that the process is reversible.

In the long run, speed management can affect traffic volumes on the roads. Studies on the impacts of (changes in) speed often consider only link level impacts, which usually means assuming that traffic volumes remain unaffected. Network level studies that also take into account the (indirect) impacts on traffic volumes are more laborious and rare. A particular problem with the assessment of network level impacts is the lack of knowledge of the elasticity between speed and traffic volume (Kallberg & Toivanen, 1998).

2.5. Policy considerations

There is no doubt that technological progress is continuing to make it possible to travel faster by road transport. However, excessive or inappropriate speed has significant adverse impacts that public authorities need to carefully assess for the society as a whole.

Speeding – which encompasses excessive speed (*i.e.* driving above the speed limits) or inappropriate speed (driving too fast for the prevailing conditions, but within the limits) – is dangerous. As well as being a causation factor in around one third of fatal accidents, speed is an aggravating factor in the severity of all accidents.

The impact of speed on accidents is a particular concern in urban areas, where roads are shared by a diversity of users: car drivers, cyclists, pedestrians, etc. There is a threshold speed above which the human body can not physically survive an accident. Above an impact speed of around 45km/h, 50% of pedestrians hit by a car will not usually survive. There is therefore a compelling human need to ensure speeds are not excessive. This is fundamentally important and calls for an in-depth review of speeds, particularly in urban areas.

Public authorities have responsibility for the sustainable mobility of their citizens, but it would not be responsible for mobility to be promoted at the cost of human life. To reduce road trauma, *i.e.* fatalities and injuries, governments need to take action to reduce speeds and also to reduce speed dispersion.

In addition to greatly reducing the number of accidents and fatalities and the severity of injuries, lower vehicle speeds will contribute to reductions in other negative effects such as greenhouse gas emissions, fuel consumption and noise and reduce the adverse impacts on quality of life, especially for people living in urban areas.

Speed management strategies and policies are often consistent with policy goals in other areas (*e.g.* protecting the environment) and may be embedded in wider strategies to improve road safety and the environment. These goals need to be made more prominent in order to encourage greater collaboration and cooperation and to increase the political and public acceptance and the readiness to take action against speeding. With appropriate political support, speed management strategies can make a real contribution to achieving the triple goals of improved road safety, environmental benefits and moderation of energy consumption.

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CHAPTER 3.

THE EXTENT OF EXCESSIVE SPEED AND OPINIONS ABOUT SPEED

This chapter focuses on excessive speed (driving above the speed limit). Driving at excessive speed is a mass phenomenon involving the vast majority of drivers which has been linked to the trends over many years in improving motor vehicle performance and transport infrastructure. Excessive speed is evident over the entire road network and is a problem common to all countries. The chapter illustrates the extent of speeding (above legal limits) taking into account responses to a survey of OECD and ECMT member countries. It also presents information on recent changes in drivers' opinions about speed, based on the European SARTRE project, which involved 23 countries, and North American surveys on speeding.

3.1. Extent of excessive speed

Excessive speed (*i.e.* driving above the speed limit) is a widespread social phenomenon in many countries. A large number of road users drive above limits set by national or local authorities on all types of roads: urban and interurban. The proportion of car drivers above the speed limit for different types of roads in a selection of OECD/ECMT countries is shown in Table 3.1, which is drawn from the responses to the survey undertaken by the Working Group in 2004.

Although the situation is different for each country, the table nevertheless shows that excessive speed is a problem that affects the entire road network in all countries. Typically 40 to 50%, and up to 80%, of drivers are driving above the posted speed limits. Further details can be found in Annex B.

Table 3.1. **Proportion of drivers of passenger cars above the speed limits on different types of roads in a selection of OECD/ECMT countries in 2003**

	Motorways		**Rural roads**		**Urban roads**	
	Speed Limit	% above the limit	Speed Limit	% above the limit	Speed Limit	% above the limit
Austria (2004)	130 km/h	23%	100km/h	18%	50 km/h 30 km/h	51% 78%
Canada	110 km/h 100 km/h	15 to 53% 15 to 81%	80 km/h	15 to 45%		
Denmark	110 km/h	72%	80 km/h	61%	50 km/h	60%
Iceland	90 km/h	80%	90 km/h	77%		
Ireland	70 mph	23%	60 mph	8%	40 mph (arterial rd) 30 mph (arterial rd) 30 mph (local str)	75% 86% 36%
Korea	100-110 km/h	50%	60km/h	not available		
Netherlands	100 km/h 120 km/h	45% 40%	80 km/h	Approx. 45%	50 km/h (arterial rd) 50 km/h (local str)	73% approx. 45%
Portugal	120 km/h	46%	90 km/h	55%	80 km/h (arterial rd) 50 km/h (collector strs)	50% 70%
Sweden	110 km/h	68%	30 to 110 km/h	58% (all state roads)		
Switzerland	120 km/h	38%	80 km/h	24%	50 km/h (arterial rd)	21%
United Kingdom	70 mph	57%	60 mph	9%	40 mph (arterial rd) 30 mph (local str)	27% 58%
United States	55-65 mph, varying from state to state	40-70%	55 mph	47%	40 mph (arterial rd) 30 mph (local str)	73% 74%

Source: OECD/ECMT survey (2004). See more details in Annex B.

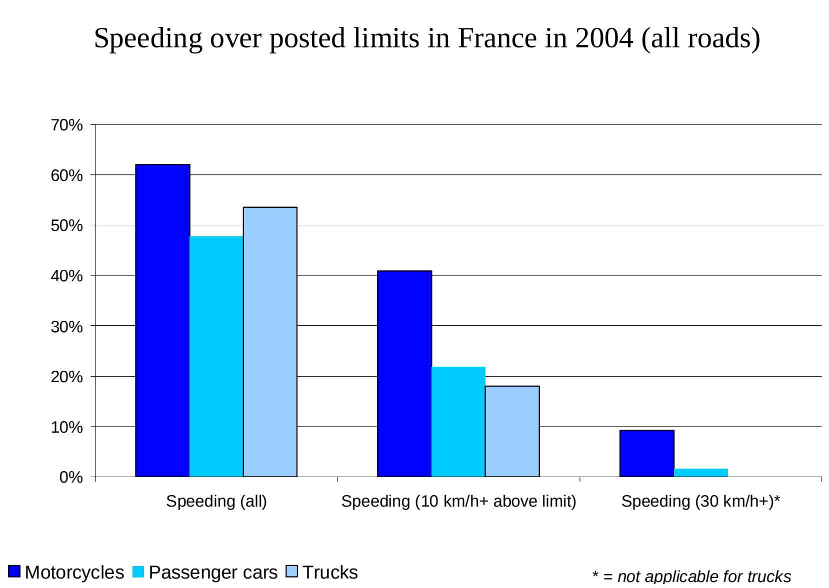
A distinction must be made between those who drive a few km/h above the speed limits (most drivers) and those who drive excessively above the speed limits, which generally involves a small proportion of the drivers.

Figure 3.1 shows the proportion of drivers in France driving above the speed limit and a breakdown that shows the proportion that exceed the speed limit by 10 km/h or more and 30 km/h or more. For car drivers, it shows that 48% of drivers exceed the limit; and 3% go 30 km/h or more above the posted limit. Motorcyclists represent the road user category with the highest rates of speeding, with more than 60% of motorcyclists driving over the speed limits (see also the section below on *different types of road users*).

In the United Kingdom, 55% of passenger vehicles are travelling faster than the 70 mph limit and 19% are driving above 80 mph (OECD, 2002). In the United States, a survey on speeding (NHTSA, 2003) indicates that while at least three-quarters of drivers admit to driving over the speed limit, most seem to set a boundary as to how much over the limit they will travel on different types of roads. Many drivers report driving 10 mph over the speed limit on interstate highways (51%) and driving 10 mph faster than most other vehicles (34%). However, a relatively smaller proportion reports similar behaviours at higher speeds, including driving 20 mph over the speed limit on interstate highways (12%) and driving 20 mph faster than most other vehicles (10%). As an example of the range of speeding behaviour in a national context, Table 3.2 illustrates the proportion of drivers travelling above the speed limit in Portugal by the magnitude of excessive speed. It shows that 80% of speeding occurrences are between 0 and 30 km/h above the speed limit.

However, as noted in Chapter 2 on the Effects of Speed, even if the proportion of very excessive speeding is relatively small, these behaviours are the most dangerous and the cause of very severe accidents.

Figure 3.1. **Proportion of drivers exceeding speed limit in France on motorways by category of road users**



Source: French ONISR (2005).

Table 3.2. **Proportion of drivers in Portugal travelling above the speed limit**

Road Category	Speed Limit	Proportion of drivers travelling above the posted limits
Motorways / freeways	120 km/h	46% drive above the limit - 37% drive up to 150 km/h - 9% drive above 150 km/h 1% drive above 180 km/h
Main highways (undivided carriageways)	90 km/h	65% drive above the limit - 52% drive up to 120 km/h - 13% drive above 120 km/h 2% drive above 150 km/h

Source: OECD/ECMT survey (2004).

Vehicle performance

The extent of excessive speed, at least for the motorway network, is undoubtedly linked to increasing vehicle performance. In 2004, 99% of the new vehicles sold could reach 150 km/h or more, which for most countries is above the maximum authorised speed on motorways.

Road design

Road design, too, has a direct impact on actual speeds. Road widening, which was often undertaken in the 1970s and 1980s to increase road capacity considered insufficient at certain periods of the day or year, may encourage excessive speed, particularly when the traffic volume is low and in the absence of any speed moderating measures, such as traffic calming.

Different types of road user

As Figure 3.1 indicates for France, the road users most likely to exceed the speed limit are motorcyclists, followed by drivers of passenger cars. However, a large number of drivers of heavy vehicles also go beyond the specified limits. In France, on national highways where the speed limit is 90 km/h, the French ONISR (2005) study found the average speed was 96 km/h for motorcycles, 84 km/h for passenger vehicles and 77 km/h for heavy vehicles. However, on through roads in built-up areas, where the speed limit is 50 km/h, heavy vehicles had an average speed of 54 km/h, which means that a large share of these drivers was breaking the law (see also table 3.3).

Based on a recent study conducted in Virginia (United States) by the U.S. Insurance Institute for Highway Safety, speeders (defined as those driving 15 mph above the limit) are younger than drivers in the comparison group, drive newer vehicles, and have more speeding violations and other driving violations on their records. They also had 60 percent more crashes (William *et* al, 2005).

Time of the day

Excessive speed is proportionally higher during those periods when the traffic is most fluid.

The levels of excessive speed in France for passenger cars, including the percentage of drivers at 10% or more above the speed limit during the day and at night time, are illustrated in Table 3.3. The table shows that, except on motorways, the extent of excessive speed is greater at night time. On national highways in France (where the speed limit is 90 km/h), rates of speeding in excess of 10 km/h above the limit range from 17% during the daytime to 23% at night, while average speeds during the day and at night time are very similar (ONISR, 2005).

Table 3.3. **Levels of excessive speed in France, for passenger cars**
2003

		Motorways (130 km/h)	In average-size cities (50km/h)	Main highways (90km/h)	Main highways through villages (50km/h)
• Average speed	Day	124 km/h	50 km/h	85 km/h	57 km/h
• Percentage of drivers above limits	Day	42%	47%	38%	72%
• Percentage of drivers 10% or more above the speed limit	Day	22%	17%	17%	35%
• Average speed	Night	114 km/h	54 km/h	88 km/h	63 km/h
• Percentage of drivers above limits	Night	37%	62%	44%	85%
• Percentage of drivers 10% or more above the speed limit	Night	26%	27%	23%	55%

Source: Observatoire National Interministériel de la Sécurité Routière (2004).

A large variation in speeding rate according to the time of day has also been found. Usually, excessive speeds are more frequent in the early morning compared to the middle of the day (Nouvier, 1990).

3.2. Some psychological considerations related to speed

Influence of speed limits

Studies examining the contribution of speed limits to speeding behaviour show that drivers do not usually comply strictly with speed limits. The extent of speeding varies depending on the reasonableness of the speed limit, the driving context and the driver's own characteristics. The diversity of behaviours observed in response to the same road situation clearly illustrates this fact. It is also worth noting that similar diversity has also been reported with regard to a variety of road configurations (Haglund and Aberg, 2000). Drivers' attitudes to speed limits, the importance they attach to compliance with local traffic conditions, as well as their perceptions of the speeds of other road users, also account for the diversity of speed adjustments made by drivers.

The degree of compliance with the speed limit results from drivers' appraisals of both the utility and the disutility of non-compliance. The perceived utility of non-compliance is basically related to the desire to reduce travel time as well as thrill-seeking, with the latter probably affecting the extreme cases of non-compliance (very high speeds). The disutility of non-compliance relates to the fear of being penalised, fuel consumption, accident risk, vehicle deterioration and pollution.

The high percentage of drivers speeding excessively can in some cases be explained by the "contradiction" between the road design and the speed limit on that road. Speed limits are not always credible for the road users. Often, the speed limit is justified (for example, by the presence of vulnerable road users) but the road design is not in accordance with the appropriate speed and calls for further infrastructure measures (speed humps, for example).

Differences between drivers in different situations

Individual driver behaviour has, of course, a significant effect on driving speed. Driving speeds can exceed the legal limit by varying degrees according to context and the drivers' personal tendencies. Differences between drivers can be important. The extent of speeding behaviour has been demonstrated by Biecheler and Peytavin (1997) in a study examining 19 trunk roads through towns where 50 km/h speed limits were in force. The results reveal major disparities in the average speed of vehicles and the percentage of drivers exceeding the speed limit, depending on the sites and the time of day (the average speeds observed at different sites varied from 52 km/h to 81 km/h and the proportion of drivers speeding from 54% to 100%). These findings are a good example of how the legal speed limit can fall short of its aim of ensuring that drivers behave appropriately.

Many drivers assume that they are able to control their vehicles even when driving at high speed. These motorists tend to consider themselves as safe drivers who would never be responsible for an accident. For them, the probability of being punished by the law is the main reason for avoiding driving at high speed.

Speed and local social norms

Speed limits (posted or not, general or local) are not the only factor considered by drivers to choose their speed. The behaviour of other drivers has an influence which may be seen as a social norm.

Biecheler and Peytavin (1997) examined the tendency of drivers to comply with speed limits or with a "local social norm". To measure the degree of compliance with the "local social norm", the authors noted the difference between the speed of each individual driver and the average speed of traffic observed at the site. They then classified drivers according to two different dimensions, a "legality" dimension, reflecting a tendency to respect the speed limit, and a "social conformity" dimension, reflecting a tendency to comply with the speed of other road users. This allowed them to distinguish between three major categories of driver, each with different basic tendencies:

- Drivers who drive more slowly than the average traffic speed and who usually drive at speeds below the legal limit.
- Drivers who drive at more or less the average speed.
- Drivers who drive at higher speeds that are mainly over the legal speed limit. It was observed that 70% of drivers drove at speeds above the legal limit, this percentage being made up of 40% driving at average traffic speed, and 30% driving faster than the average traffic speed and therefore above both the legal limit and the "local social norm".

Aberg *et al*. (1997) studied the same phenomenon by observing speeds on eleven main roads traversing built-up areas with a speed limit of 50 km/h, and then questioning drivers both on the spot and by questionnaire. The study showed that over 50% of drivers failed to respect speed limits despite most claiming to be in favour of compliance. It was concluded that variables other than willingness to obey the law must influence observed speeds. Interestingly, the authors noted that most drivers overestimate the speeds of other drivers, suggesting that drivers' perceptions of other vehicle speeds are not accurate. As many drivers also state that they want to travel at the same speed as other road users, inaccurate estimation of the speed of other road users is probably one of the factors that accounts for speeding. The results showed that drivers who were less negative towards speeding drove faster than other drivers. The drivers who thought that other road users were driving fast, or who wanted to drive like other road users, maintained a higher speed than other drivers.

An observational study by Lerner *et al*. (2005) investigated teen driving as a function of passenger presence and passenger gender. Vehicles were observed leaving high school parking lots at dismissal time, and the apparent age, gender of drivers and passengers were recorded; vehicle speeds and headways were then recorded at sites near the school. Results show that while teens as a group drove slightly faster than general traffic, and male teens drove slightly faster than female teens, the primary influence on speed was the presence of a male passenger. For the male driver group, the difference in speed between the male passenger and female passenger conditions was almost 8 km/h.

Perception of speed by drivers

Distortions in speed estimation may also be observed when a driver has to change speed (accelerate or decelerate). For example, the greater the deceleration, the greater the error in the estimation of the subsequent speed (Denton, 1967). Similarly, Salvatore (1967) showed that the greater the rate of change, the greater the distortion in the estimation of speeds. As a general rule, the findings show that drivers usually produce a smaller change in speed than that required. Recarte *et al.* (2002) observed the same tendencies in real driving situations and noted that the absolute error is greater after decelerating than after accelerating. This phenomenon highlights the problems that drivers can face in managing “transitional situations”, that is to say situations in which they need to adjust their speed significantly (Saad, 1983).

It has also been found that a driver who has been driving for a long time on motorways tends to drive significantly faster than other drivers after he has left the motorway (Nouvier, 1987).

The perception of speed can be affected by the phenomenon of adaptation, which reduces the sensation of speed the longer the driver remains behind the wheel. Schmidt and Tiffin (1969) studied the impact of an exposure to a high initial speed on the estimation of a lower speed following deceleration. They noted that the longer the period of exposure to the initial speed, the greater the error in drivers’ perception of the subsequent speed (underestimation of the actual speed). Denton (1972) observed the same phenomenon when asking drivers to maintain a constant speed for various periods of time. Because of the adaptation phenomenon, drivers gradually increased their speed over time to maintain a feeling of constant speed. Speed adaptation in real driving situations was observed by Matthews (1978) and later verified by Casey and Lund (1987).

A road and its environment are perceived via central and peripheral vision. Early studies in the 1960s revealed the primordial role played by peripheral vision in estimating driving speeds (Salvatore, 1967). Speeds are estimated more precisely in peripheral vision, but are underestimated in central vision. These studies thus revealed the influence of the size of the field of vision on the perception of speed and explain why, for example, drivers underestimate speed on wide roads that lack points of reference.

In short, by identifying the variables that affect the perception of speed, it is possible to determine some situations that are “critical” in terms of drivers’ perception of speed:

- Driving situations in which a given speed is maintained over a long period of time (such as long-distance trips on motorways);

- “Transitional” situations in which drivers must significantly adjust the speed of their vehicles to comply with new regulatory and/or functional requirements (such as driving along trunk roads routed through small towns or around bends at the end of a long straight section of road);

- Situations in which peripheral visual information is reduced (*e.g.* wide roads without any points of reference, driving at night or in fog).

Public attitudes towards speeding

Another interesting factor is the change in public attitudes towards speeding. In several countries one can observe a growing awareness of road safety issues and the need to manage speed, as shown in the responses to the survey conducted by the working group (see Annex B). There is overall a greater acceptability of the speed limits and of speed enforcement measures than in the past.

The survey also showed that in several countries, there is "pressure" from the public to increase speed limits on motorways (especially in the countries where limits are the lowest), and to lower speed limits on urban roads. Almost all countries that responded indicated that there is increasing pressure by the public at large to decrease speed limits in residential areas to 30 km/h.

3.3. Opinion surveys conducted in Europe and North America

This section outlines some of the conclusions of recent projects on opinions about speed in Europe (SARTRE 3 project), in the United States (NHTSA speed survey) and in Canada. Annex B contains further information on recent evolution in public's attitudes towards speeding, based on the responses to the questionnaire.

> ***While the three studies provide useful indications on the opinions of drivers about speed, it should be highlighted that these studies are based on declared opinions only, which often do not match actual behaviour. Europe: SARTRE 3 project***

The SARTRE project is a research project, funded by the European Commission, aimed at studying the opinions and reported behaviours of car drivers throughout Europe. SARTRE is the acronym for Social Attitudes to Road Traffic Risk in Europe.

SARTRE 3 is the third in the series of surveys and was conducted in 2002. It covered many dimensions of road safety, including speed. The following are the key conclusions on the declared attitude of European drivers towards speed (European Commission, 2004):

- The majority of drivers (more than 70%) think that drivers frequently exceed speed limits.
- 84% of drivers think that other road users drive above the limit.
- A significant proportion of drivers enjoy driving fast (36%). More male drivers reported driving fast than female, as did younger drivers, people who are employed, those with a higher income, single people, people from urban environments and frequent drivers.
- Nearly 20% of European drivers (34% of Dutch drivers and 13% of Austrian drivers) say that they themselves drive faster than the average driver.
- Driving too fast is widely recognised as being a contributory factor in accidents (82%).
- One out of five European drivers has been fined for excessive speed within the past three years.

- There is widespread support for the installation of speed limiting devices and “black boxes” in vehicles (62%). Additionally, support for road safety measures such as speed limiters and advertising restrictions appears to be increasing over time, but with wide variations by country.

The main recommendations of the SARTRE 3 project related to speed can be summarised as follows:

- Intensification of speed enforcement is considered a priority safety measure in several European countries.

- In countries with a low degree of acceptance of speed enforcement, information campaigns should both precede and accompany the enforcement intensification.

- Finally, it is recommended that road safety campaigns focusing on inappropriate speeding should be specially designed for each country (or region), as speeding behaviour shows important differences among the European countries.

United States: NHTSA Survey on speeding and unsafe driving

NHTSA first conducted a study on the driving public’s attitudes and behaviour regarding speeding and unsafe behaviours in 1997. In 2002, NHTSA undertook a second survey of drivers to collect updated data on the nature and scope of the speeding and unsafe driving problem with the intent of gauging how serious the problem is in the public’s eyes, and what measures the public may accept to counter these problems.

Affinity for speeding

Speeding is a pervasive behaviour, with about three-quarters of drivers reporting they had driven over the speed limit on all types of roads within the past month, and one-quarter or more reporting having driven over the speed limit on the day of interview (reported below as "today"). Self-reported behaviours in the past month, and the most recent day, include speeding on:

- Multi-lane interstate highways (78% in past month and 25% today).
- Two-lane roads (78% and 31%).
- City, town, or neighbourhood streets (73% and 33%).
- Non-interstate multi-lane roads (83% and 31%).

A majority of drivers of all ages admit to speeding. However:

- Younger drivers are most likely to report speeding at least monthly, with eight out of ten speeding on each road type.
- Males are 50% more likely than females to report driving over the posted speed limit.
- Of those age 65 or older, six out of ten report speeding on all road types.

Opinions about speed limits

Enforcement tolerance:

Drivers believe they can travel 7-8 mph over the posted speed limit, on average, before police would give them a ticket.

Appropriateness of existing speed limits:

While three-quarters or more of drivers admit to exceeding the limit on all road types, most drivers (from 61% for multi-lane interstate highways to 83 % for city, town or neighbourhood roads) feel that the existing speed limits on roads are appropriate.

Factors affecting speed selection by motorists:

Drivers were asked to rate how important various factors were to them in selecting the speed. From their responses, the five most important factors they consider when selecting road speed (across different roadway types) are:

- Weather conditions.
- Driver's personal assessment of a "safe" speed.
- Posted speed limits.
- The amount of traffic on the road.
- Driver's personal experience on that road.

The following factors were very important to 50%, or less, of drivers when selecting road speed:

- Speed of other drivers (50%).
- The chance of being stopped by police (50%).
- Amount of time driver has to get to their destination (33%).

Canada: Survey and focus group testing on driver attitudes to speeding and speed management

A recent Canadian phone study (2005), with further in-depth focus group sessions, found that about 10% of Canadian drivers have been involved in a collision which resulted in an injury requiring hospitalization. This result did not seem to be related to self-reports of speeding or length of licensure. Most drivers (62%) admit to at least one speeding ticket, and the average was 3.7. However, 10% of drivers admit to having received more than six speeding tickets.

Speeding was selected as a top cause of collisions by 47% of respondents. When asked to define speeding, three themes were identified:

- A technical definition, which was normally associated with governments and police but often considered unrealistic;

- A relative definition was considered more realistic. The relationship was with traffic, weather conditions and the flow of traffic; and

- An absolute value was often mentioned, which changed by road type or posted speed limit, with the higher limits supporting a higher variance.

Where and by how much people speed is very dependent on the roadway. Frequent speeding behaviour was reported on major highways (58%), 2-lane highways and country roads (39%) and residential streets (13%).

People perceive others to speed more often than themselves. While respondents felt only 1% of all drivers never speed, 29% reported that they never speed, whereas 50% of drivers report speeding frequently while feeling 88% of others speed frequently.

Many drivers indicated a limit to the speed over the posted limit they will accept. For example, of drivers who speed, 81% would not exceed 120 km/h in a 100 km/h zone. Only 1 in 50 drivers would admit to exceeding 130 km/h in the same zone. However, drivers who admit to speeding frequently report driving at higher speeds over the limit.

Respondents indicated that time was a common factor in their speeding behaviour (35%) as was feeling the speed limit was set too low (32%) and not paying attention to their speed (28%). Drivers in the latter group indicated they typically exceed the limit by less than 10 percent. When asked to rate their agreement with statements regarding speeding, 52% agreed that drivers should keep up with the flow of traffic regardless of the speed limit. As well, 41% agreed police do not enforce the limit enough and that speed limits are set too low. Interestingly, only 31% of drivers unequivocally believed speeding saves time. A majority indicated situational factors play a significant role, for example, city driving versus long distance highway driving.

When asked about the disadvantages of speeding, 54% indicated a higher collision risk, 35% indicated a risk of a ticket while 31% identified a higher risk of injury given a collision. On the other hand, only 18% indicated the adverse impact on fuel economy and 6% identified increased emissions as a disadvantage.

Respondents were asked to rate how good an idea various countermeasures were. The results were:

- Electronic road signs indicating speeding behaviour 72%
- Increased police enforcement 67%
- In-vehicle driver information systems 63%
- Black box collision reporting of speeding 62%
- Publicity and information campaigns 58%
- Photo radar 56%
- Doubling speeding fines 52%
- Roadway modification 47%
- In-vehicle technology reporting to insurance 38%
- Reducing speed limits on residential streets 35%
- In-vehicle speed control, *e.g.* ISA 35%
- Reducing speed limits on 2 lane roads 21%

Respondents generally did indicate that more information regarding the environmental impacts of speeding should be communicated more widely.

3.4. Policy considerations

Excessive speed is a widespread social problem, which affects the entire road network (motorways, main highways, rural roads, urban roads). Typically, at any time, 50% of drivers are driving above the speed limits. Excessive speed involves all types of motor vehicles (cars, motorcycles, trucks).

Speed is recognised by the majority of the population as being a major safety problem but, at the same time, is considered to be a problem that concerns “other” drivers.

The majority of cases of speed limit excedence involve driving less than 10 km/h above the limit. Speed moderation measures should target both “big” offences and also “small” speed limit excedence offences, as small limit excedence by a large number of road users has a significant impact on accident risk (see chapter 2).

In many OECD/ECMT countries, over the past few years there has been a positive change in public opinion and a growing awareness of the problem of speed. Nevertheless, a gradual increase in actual average speeds can be observed in these same countries.

To have an effective impact on driver behaviour, speed countermeasures must take into account the psychological aspects of speed perception. This is particularly important when addressing the issue of speed reductions required in transition situations (*e.g.* entering urban areas).

To address the problem of excessive speed on the roads, speed management measures must be developed on a very large scale: for all types of vehicles, on all types of roads. This requires the involvement of a variety of actors in the transport field, especially authorities responsible for road transport systems, as well as other stakeholders and the community generally.

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PART II: HOW TO ADDRESS THE PROBLEM OF SPEEDING?

Part I of the report described why speed is a problem. While recognising that higher travel speed has generated many benefits, it highlights the impact of speed not only on road safety, but also on the environment, the quality of life and to some extent on land use planning. It also shows that speeding, *i.e.* driving at excessive speed or inappropriate speed, is a common phenomenon that affects all types of drivers, the entire road network and all countries. The outcome is that speeds chosen by drivers on the basis of their individual perceptions and preferences only rarely coincide with the appropriate speed – from the point of view of society as a whole – taking into account safety, noise and pollution impacts.

Part I therefore calls for the implementation of measures to influence drivers' behaviour and reduce vehicle speeds as well as to reduce the variation of speeds in actual traffic flows.

Part II focuses on how to address the problem of speeding and outlines proposed responses to the problem of excessive speed.

A variety of measures already exist and have proven their efficiency in some countries. However they have not yet been fully implemented in many countries. These measures include: infrastructure-related measures, speed limits; signs, signals and markings; vehicle technologies; education, training and incentives; enforcement; and new technologies. Part II describes these individual measures, highlights best practices in OECD/ECMT countries and stresses the necessity to combine these measures into a speed management policy in order to achieve the best outcome.

If we had to develop a completely new road transport system – which for most countries would be a purely theoretical exercise – the following would be the sequence of events: We would build new roads, each having a clear and well defined function, which would be reflected in its design. By their design and construction, these roads would guide the drivers into driving at the appropriate speeds. To guide them even further, we would post signs with speed limits, which would be fully credible and compatible with the appropriate speed. Dynamic speed limits would be used as often as possible, taking full account of the specific local conditions. To assist the driver further, we would design clear marking on the road and build clear signs to provide the driver with relevant information on the speed to be adopted. At the same time, vehicles would be designed in a way that would not encourage drivers to go fast. To make drivers aware of the danger of too high speeds we would develop information campaigns, we would educate the population from their childhood about the dangers of high speed and, during their training courses, drivers would be taught about the adverse impacts of driving at high speeds. Despite all this, some drivers could – voluntarily but also inadvertently – drive too fast for the prevailing conditions. To avoid this, we would develop an enforcement strategy by implementing both manual and automatic enforcement. In a longer term, to avoid "inadvertent" speeding, cars would be equipped with technologies to warn the drivers when driving too fast and possibly to control the speed of the vehicle. Further technologies would continue to develop. All these measures would be implemented in harmony, with each actor of the chain well informed about the actions taken by the others. In turn, excessive and inappropriate speed would only be an exceptional event.

Let's go back to reality, where roads are already built, vehicles are already designed and the drivers not always well informed or responsive to the dangers of speeding. The approach should still follow the same general rationale.

The first idea is – to the extent possible – to make the existing roads "self explaining", *i.e.* to build and modify the relevant infrastructure to encourage the driver to choose the appropriate speed. Chapter 4 describes the different infrastructure measures that can be implemented in rural areas, in urban areas and for transition zones.

Then, Chapter 5 presents the basis for national speed limit regimes, as well as for local speed limits. The bases for the assessment of appropriate speeds and hence speed limits, are presented. It is emphasized that a speed limit — based on protection of human life and avoidance of serious injuries and also taking account mobility, environmental considerations and quality of life — is only one aspect of achieving appropriate speed; road engineering measures, as well as information, education and enforcement should also accompany the use of speed limits.

Once speed limits have been decided and set up, road users need to be made aware of these limits. Chapter 6 describes the options for informing the drivers of the speed limits in force and also identifies their means of communication. This includes traditional signing and signals as well as road marking. In addition, variable message signs are becoming a more widely used tool.

The vehicle itself is of course an important contributing factor to the speed issues. The engine power and vehicle performance are key inputs but the overall design of the vehicle and technologies such as cruise control, speed limiters or event data records can also have an important impact on speed. This interaction is analysed in Chapter 7.

The driver is naturally the key actor in the choice of travel speed so drivers should be adequately informed and trained. Chapter 8 reviews current experience with education from childhood, with driver training, including simulation driving and with information campaigns.

If all the above measures were fully implemented, perhaps enforcement would be optional. Unfortunately, the system is not perfect and drivers are not perfect. Enforcement is therefore an important and, in fact, an indispensable supporting measure. Chapter 9 describes current practices with enforcement.

In the future, other possibilities for driving assistance and vehicle speed control will be offered by the latest technology and telematic tools. Development of Intelligent Speed Adaptation (ISA) technologies is well on track and offers promising prospects for assisting in speed reduction. Other new technologies, such as advanced Event Data Recorders (EDRs) also offer encouraging prospects. These new technologies are described in Chapter 10.

Finally, Part III deals with the Evaluation Framework. It stresses the need to consider all the above measures in an integrated speed management framework in order to find synergies between measures and to reach the best possible outcomes in the most cost effective way. It shows the desirable involvement of the various actors and the consequences of speed management for different groups in society as well as on flora and fauna. It also points out that each package of measures should be tailored for each country, and that countries with good road safety performance need a different package from countries with lower levels of road safety performance.

CHAPTER 4.

ROAD CATEGORISATION AND ROAD ENGINEERING

This chapter describes infrastructure measures that can help manage speed and therefore form an important part of a speed management policy. The chapter highlights the need to have sound functional classifications of the road network, and the importance of each road being "self explaining", in the sense that drivers should be guided by the road and its environment to choose the appropriate driving speed. The chapter reviews best practice measures for built-up and non built-up areas, and transition zones, and a range of technical infrastructure measures which have proven their effectiveness. Finally the chapter focuses on some key implementation issues which need to be addressed.

4.1 Introduction

Infrastructure, or road engineering, measures can make a very effective contribution to managing speed on the roads. Overall, results show that a change in the appearance of the road through changes in infrastructure is needed to influence drivers' speeding behaviour, not only in the short term but in the longer term as well. By comparison, where speed limits have been changed but no other action such as infrastructure changes taken, research has indicated that the change in average speed has only been about one quarter of the change of the speed limit (DETR, 2000, Parker 1997, Transport Canada, 1997).

Changes to road infrastructure which achieve more consistent infrastructure and reflect the needs of all road users are important not only as speed management techniques able to be employed by transport administrations, but also because they can make the streets and spaces in our cities and villages safer for pedestrians and other vulnerable road users whilst at the same time ensuring safer mobility for the driving public.

This chapter focuses on infrastructure measures ranging from standardising road classifications to physical improvements through infrastructure construction and improvement. Signing and marking, including traffic operation systems, are dealt with in Chapter 6.

4.2 History of infrastructure speed management

Changing the appearance of the road to influence speeds by the use of road engineering measures is well established in built-up areas but is less well used in non-built-up areas. In the Middle Ages, gates in fortified cities defined the need for different behaviour. This idea has been used in modern design in many cities and villages as one of the most important speed management measures which can identify the need for different driver behaviour in transition zones between non-built up roads and built-up roads where there is a need for slower speeds to protect the vulnerable road users.

Traffic calming, a general description of the methods used to physically enforce lower traffic speeds and to reduce traffic volumes, also has a long history. Early efforts were made in Radburn (United States) in the late 1920s by redesigning urban streets and places with the aim of reducing traffic volumes. In the 1960s, this approach was further developed in Europe, with the first guidelines in Sweden promoting the development of residential areas accessed by a system of ring roads (Swedish National Board of Urban Planning, 1968). These ideas spread quickly to other countries. At around the same time, the "Woonerf" (which means "living street") concept appeared in Delft in the Netherlands. Since then, speed management via infrastructure measures in urban areas has become increasingly popular and has contributed to saving lives in many cities of the world.

From the 1990s, traffic calming and other speed management techniques spread not only through urban areas, but also started to be implemented on rural roads, *e.g.* in Denmark, Netherlands and Great Britain. Nowadays speed management through infrastructure changes is a significant part of policy and operational decisions concerning roads and road traffic.

Infrastructure changes aimed at managing speeds have now extended well beyond traffic calming in built-up residential streets, with variations of such approaches now applied to all types of roads including motorways and main highways as well as urban arterial roads needing speed management to cope more safely with increasing flows of fast moving traffic.

4.3. Road function and road category as a basis for self explaining roads

A growing number of countries are looking at new approaches to road function as a basis for standardised and largely self-explaining roads. This process started many years ago when early studies in the sixties revealed the critical role played by *peripheral vision* in estimating driving speeds (Salvatore, 1967 and 1968). As already mentioned in Chapter 3, speeds are estimated more precisely in peripheral vision, but are underestimated in central vision. These studies revealed the influence of the range of the field of vision on the perception of speed, and explain, for example, why drivers underestimate speed on wide roads that lack points of reference.

During the 1960s and 1970s, a research group in Sweden developed guidelines for urban planning with regard to traffic safety – know as the SCAFT Guideline. This guideline recommended a traffic environment that has an uncomplicated design and is easy to interpret (Swedish National Board of Urban Planning, 1968).

Further concepts emerged in the 1980s, such as “Positive Guidance” (Alexander and Lunenfeld, 1986), “Road Readability” (Mazet, Dubois and Fleury, 1987) and “Self-Explaining Roads” (Theeuwes and Godthelp, 1995). These all stressed the importance of road design in assisting drivers to choose an appropriate speed. The proposed approach emphasises the need to structure the road network by adopting homogeneous and consistent design principles, which will help reduce the variability of designs in the current road stock.

All these concepts advocate a road infrastructure that elicits safe driving behaviour “by design”. This could be achieved by identifying and taking account of drivers’ knowledge and information processing, which plays a critical role in the identification and interpretation of road situations. From this perspective, a certain amount of research has been undertaken to discover the content and organisation of drivers’ knowledge about different types of road infrastructure (urban or rural roads, intersections and curves, for example). The underlying assumption of this research, which falls within the cognitive theory of knowledge organised by category in people’s memory (Rosch, 1978), is that the driver acquires knowledge about the road environment with experience and organises it into road categories.

A number of countries classify their roads according to three basic functions.

Basic road functions

Flow function

Roads with a flow function allow efficient throughput of long distance traffic. Motorways and express roads, as well as some urban arterials, have a flow function. Other traffic modes and vulnerable road users must be strictly separated. The number of access and exit points is limited and there is a significant minimum distance between intersections.

Distribution function

Roads with a distributor function allow drivers to enter and exit all kinds of urban or rural areas at intervals along the road. Intersections are much more frequent and allow at-grade traffic exchange (changes in direction etc.). Such roads are also widely used by different modes of public transport.

Access function

Roads with an access function allow actual access to properties alongside the road or street. Both intersections and road links make provision for traffic exchange. At such locations, road-engineering measures may be required to support the low speed requirement.

Categories of roads

In addition to their functions, roads are often classified according to their location (built-up areas/ outside built-up areas) and types (*e.g.* motorways). Table 4.1 summarises the different categories and functions of roads.

Table 4.1. **Road categories and functions**

Environment	Category of roads	Main functions
Outside built-up areas	Motorway (interurban)	Flow
	Main highways (principal inter urban roads)	Flow
	Rural main roads	Flow / distribution
	Rural minor roads	Access
Built-up areas	Motorways (urban)	Flow
	Urban arterial roads and main roads	Flow / distribution
	Urban residential roads	Access

The intention is that roads are to be self-explaining, in accordance with their function. Therefore, typical cross-sections and basic forms of intersections, as well as the operational mode and an appropriate speed limit, have to be determined for the types of road functions described above. In addition, elements of horizontal and vertical alignment have to be chosen in accordance with the main function of the roads and thus with their desired speeds.

Design speed

In some countries a new approach to design speed is now broadly used, which is evident in recent definitions of design speed. The design speed of a road can be defined as: *the highest speed that can be maintained safely and comfortably when traffic is light* (*e.g.* ETSC, 1995). This definition is very different from the former definition, when design speed was generally defined as a speed that can be maintained safely by the average driver with an average car in good weather conditions.

In principle, the required design speed depends on the function of the road and, hence, on the desired speed level. If, because of the road function, high speeds are desired, road quality and roadside protection need to be of an appropriate standard. The alternative to improving road standard is to reduce the speed limit and actual speeds, consistent with the standard and risk of the road.

Clearly, the design speed must never be lower than the speed limit. On the other hand, it is not wise to have a speed limit which is much lower than the design speed of a road. This may damage the credibility of the speed limit.

Furthermore, it is important that the design speed in non-built up areas is consistent over a long stretch of road. A substantial reduction of design speed at a particular site must be supported by a change in road design characteristics and appropriate road signing and markings (see Chapter 6).

4.4. Non built up areas

Motorways

Motorways are the safest road environment for fast moving traffic and, except for measures to ease congestion such as ramp metering and variable speed limits, they are not usually subject to additional infrastructure measures for speed management purposes. The exception is during road works where reduced speeds are required for workforce protection and vehicle occupant safety. Speeds in these road work zones are often managed by narrow lanes and chicanes strictly enforced by speed cameras in countries where they are allowed to operate.

Rural roads

Rural roads carry the greatest risk of death and injury with, in most industrialised countries, 60% of traffic fatalities typically occurring on rural roads. They have recently become a focus for policy and operational attention. For example, safety inspections or audits of the rural road network and changes to the speed limit to reflect more appropriate and safer speeds started in several countries (*e.g.* Great Britain, the Netherlands and Norway) just a few years ago.

Drivers running off the road and colliding with road side objects in single vehicle accidents is a major problem on the rural network in many countries. It is expensive and impractical to apply infrastructure-based speed management measures to the entire network to prevent these accidents. However, local improvements to rural roads can be made by removing roadside obstacles such as trees, utility and sign poles, to make the road safer and more forgiving in the most dangerous locations. A highly effective solution for rural roads – which requires long-term planning – would be to separate traffic travelling in opposite directions, using for example median barriers. Some countries, such as Sweden, are progressively upgrading their highest risk rural roads to this standard. However, it is evident that for most countries resource constraints prevent this measure being carried out on a large scale. In these circumstances, other alternatives need to be considered. Section control could be considered where feasible and cost effective. As well, the use of new technologies such as intelligent speed adaptation is expected to offer new prospects for managing speed on rural roads (see chapter 10).

Vehicles of different mass and vehicles travelling at different speeds can create high risk stretches of road especially where light vehicles overtake slow, heavy ones. To overcome such traffic mismatches, transport policies in several countries require separate lanes for slow moving vehicles, such as heavy vehicles and agricultural vehicles. In some countries (*e.g.* Netherlands, Austria), separate lanes (and sometimes separate roads) in rural areas are dedicated to agricultural vehicles, such as tractors (cyclists, pedestrians or horse riders are allowed to use these lanes). In practice separate lanes or roads are hard to achieve in the short term. New so-called “service” roads are expensive to construct, especially in hilly and mountainous countryside, and often there is also insufficient space to do so.

Bicyclists are especially vulnerable on rural roads and bicycles lanes have been introduced in some countries to improve their safety. Bicycle lanes – in contrast to bicycle paths – are not physically separated from the driving lane, but only visually separated from it by longitudinal markings (continuous or broken lines, sometimes of a different colour). In the Netherlands, for example, these are mainly used on 50 km/h urban roads and 60 km/h rural roads. The lanes are separated by a broken line and do not have the legal status of a bicycle lane or path. A "before-after" evaluation study on 60 km/h and 80 km/h roads of this type with non-compulsory bicycle lanes showed a slight decrease (a few km/h) in average speed (Kooi, Dijkstra 2003).

Gradients on rural roads and motorways

On rural roads and on motorways, long downhills and uphills need specific attention. In many countries, at the approach of a downhill, a sign indicates the gradient of the slope and recommends that the driver changes to a lower gear. For uphills and even downhills, the main difficulties arise from speed differentials between heavy and light vehicles. Some hilly countries also provide arrester beds in case of brake failure in heavy trucks.

In the case of uphill gradients on single carriageway rural roads, overtaking lanes can be considered – which need to be well engineered to prevent collisions in the transition areas where the overtaking lane ends – as well as dedicated lanes for slow vehicles.

4.5. Transition zones

When entering a lower speed zone, in particular after a period of driving at a high speed, drivers will generally underestimate their speed and consequently not reduce their speed enough to comply with the lower speed limit. Here specific infrastructure measures can help to indicate the transition from one traffic environment to another, and thus help drivers adjust to the lower speed.

Of special concern is the entrance to a village from a major through-road. ETSC (1995) describes two principles in such transition zones. The first principle is that complementary measures along the through-route within the urban area are required. The second principle is that measures at the transition zone should be such that they achieve a cumulative effect, finishing at the actual gateway to the town or village. The latter can be achieved, as the ETSC reports explains, by a combination of road narrowing and the introduction of trees and other vertical elements, culminating in the gateway. This is an example of a physical and also perceptive measure that relies on the driver's perception of the appropriate speed: speeds chosen are lower where the height of the vertical elements is greater than the width of the road. However the vertical elements need to be chosen very carefully so as not to become roadside obstacles which can have a negative effect on traffic safety.

4.6. Built up areas

Speed management measures in built-up urban areas can now be found in many countries. Often these measures have been implemented in response to conflicts between the needs of different groups of road users which led to an increase in accidents. This was especially the case in popular shopping areas in significant parts of towns and cities where such conflicts made them a high accident risk area, especially for pedestrians. The increase in such risks has inspired a lot of designers, as well as decision makers, to re-design urban streets and spaces, in order to decrease the space dedicated to through-traffic and to manage the speed of through-traffic on a scale much closer to the desires and needs of pedestrians, cyclists and other vulnerable road users. In addition, measures are often taken to bypass problem areas, *e.g.* new routes around the city, or redirect through-traffic to bypass pedestrian zones.

Low speeds may be crucial for road safety (perceived or actual) in particularly sensitive locations. Examples include: in residential areas, near schools or homes for the elderly, at pedestrian crossings and/or at intersections. At such locations, physical speed-reducing measures such as speed humps, cushions, road narrowings, plateaus in intersection areas and roundabouts, can help to ensure cars maintain safe speeds.

If applied in a consistent way, such infrastructure-based measures also help drivers to recognise the traffic situation and comply with the corresponding speed limit. Nevertheless, speed management involving road engineering changes always needs to be accompanied by education, information and enforcement to make road users aware of the speed and speeding problem, the "why" and "what" of countermeasures and have incentives for compliance.

Home zones, 30 km/h zones and other slow speed areas

As mentioned earlier, the name “Woonerf” appeared for the first time in Delft in the Netherlands in the late 1960s as an initiative of the citizens of Delft. This name soon became very popular in other European countries. Many other citizen coalitions, as well as local governments, have adopted the same measures in their own environment. The “Woonerf” concept works well for specific conditions in a small area (one street or a few blocks). The need for expanded areas of reduced speed led to the establishment of the Zone 30 approach – see Figure 4.1 (equivalent to 20 mph zones).

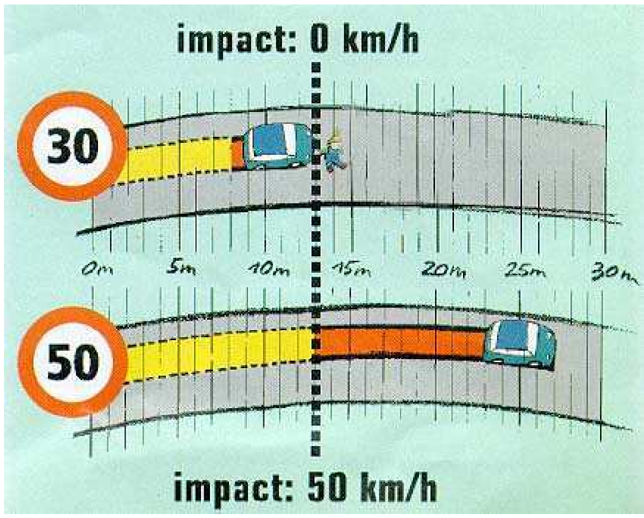
Figure 4.1. **Typical design of a 30 km/h zone**

Source: CERTU.

The first 30 km/h zones were developed in the 80s. This approach influenced road traffic safety in a similar way to that of “Woonerf”, but with fewer requirements for expensive infrastructure investment. These zones provided for access to an area by motorised vehicles, but low speeds were encouraged and enforced by varying combinations of the engineering measures. Implementation of those measures is really a key issue. Attempts to achieve the same outcomes using only signs were unsuccessful. The 30 km/h zone approach has become more and more popular. There are many cities where 30 km/h zones now make up a significant part of a whole urban road network. Graz in Austria was the first city to introduce 30 km/h zones as the general speed limit across the urban area, with higher limits on some signed arteries. Other large cities have tried to implement this approach but have found that difficulties could arise when applied to large streets with a high volume of traffic.

From a safety viewpoint, 30 km/h zones have proven to be very effective in reducing accident levels in urban areas. Webster and Mackie (1996) found that 20 mph zones led to a reduction by around 60% of injury accidents and by around 70% of fatal accidents. Of course, these good results suppose that the speed limits are respected (which means they are strictly enforced).

Figure 4.2. **Stopping distance in urban areas and impact**



Source: French Ministry of Transport.

One of the reasons for the improved outcomes is that braking distances are significantly reduced. Figure 4.2 illustrates braking distances at speeds of 30 and 50 km/h. Where there are possible conflicts with pedestrians and other vulnerable road users in urban areas, it is highly desirable to promote 30 km/h zones.

With further development of traffic calming and traffic management in cities, another approach has developed involving so-called “Step tempo” or “meeting zones”, where the whole street area is shared by all road users, with no priority regulation and a very low maximum speed (around 20 km/h). Successful experiments have been undertaken in a number of city centres and residential areas.

4.7. Engineering measures

Gates

Constructions similar to medieval gates help indicate the change from one traffic environment to another. Through the centuries, gates formed the boundary between country and city. Nowadays, the border between the city (village) and the country is less distinct and this is one of the reasons why many drivers ignore the local speed limits. Current gates have to indicate the beginning of an area where new traffic behaviour, and especially a new speed, is required. Figure 4.3 shows such a gate in Germany. Gates may be used on different roads, mostly at the border of a city, but are also found inside the city dividing different town areas, usually the town centre. Gates may be in the form of an actual building structure, as in ancient times, but they may also be constructed using different forms of plantings, lighting etc.

Figure 4.3. **Gate effect in a town in Germany**

Source: CDV.

Gates improve drivers' understanding of the different traffic behaviour required *e.g.* along the sections of road shown above. Gates should delineate the start of different road designs on the same stretch of road. If there is a cycle track through the city, it should desirably start at the gate. The change from two lanes into a single carriageway, or the narrowing of a lane should also, preferably, start at the gate.

Speed reduction at such gate depends on their design and changes in road design between previous and following road sections, as well as on the neighbouring environment. The speed reduction effect is greatest if the alignment makes a distinct steering manoeuvre necessary, and if both visual elements and other traffic calming measures, like a change in the road profile, road surface, and so on, are used.

Islands and refuge islands

Central traffic islands are often used at the entrances to urban areas, especially on the roads which pass through smaller cities or villages. Differences in function and shape are evident between the one-sided central islands dedicated to decreasing the speed on entry only, and two-sided central islands, which are intended to prevent the speed of vehicles increasing as they exit the urban area, or even inside it. Research carried out by the Transport Research Centre (CDV) in the Czech Republic showed a strong preference for two-sided islands, or a need for other traffic calming measures on the lane in the opposite direction (Heinrich *et al*., 2004). In part, this was due to the significant number of drivers using the opposite uninterrupted lane to avoid reducing their speed on one side of the island.

Figure 4.4. **Refuge in Napajedla (Czech Republic)**

Source: Doprava, 21.

Central traffic islands separate two-way traffic, prevent overtaking and may also prevent unwanted opposed turns. However, their most favourable use is for avoiding any "fence effect" of the roads on vulnerable road users. They permit pedestrians to cross the road in two stages, so that they are only exposed to one stream of traffic from one direction at a time.

Roadside refuges can form an extension of the sidewalk; these also shorten the distance between sidewalks on both sides of the street, and reduce the time needed for pedestrians to cross the road (see figure 4.4).

Narrowing

Narrowing the width of a two-lane carriageway is another change to the infrastructure which can slow the speed of traffic. Such narrowing can be made either from the middle of the road or from the sides and can be done by introducing middle islands. Other roads might be redesigned, including narrowing of the original lanes, or by establishing roadside reservations. Their influence on speed is only moderate, but in addition to this they also provide the opportunity to build a new, more attractive, urban space by dividing the old street (road) profile.

Figure 4.5. **Narrowing of a road in Loughborough (United Kingdom)**

Source: CDV.

Narrowing of road pavements is one of the infrastructure measures employed quite often for speed management purposes.

If the narrowing is achieved by road reconstruction, the extent of such narrowing will depend on the initial profile of the road and the technical standards used at the time of the road's design and (re-) construction.

Many roads dating from the 1960s or 1970s were designed to give priority to traffic flow and speed of motorised vehicles. These and other more recent roads with similar characteristics lend themselves to re-construction and narrowing and are usually treated in this way for speed management purposes.

Roundabouts and small roundabouts

Speed reduction is also particularly appropriate at "at-grade" intersections on urban and rural roads. The application of roundabouts is a very effective speed reduction measure for these locations. In addition, because the vehicles are effectively travelling in the same direction on a roundabout the angle of impact is smaller than 90 degrees, resulting in less severe consequences in the event of a collision. Based on a meta-analysis, Elvik and Vaa (2004) report an injury accident reduction of 10-40%, depending on the number of arms and the previous form of traffic control. The largest reduction was found for four-arm junctions with prior traffic signals. There was a higher reduction in fatal and serious accidents than for slight injury accidents. The effect on pedestrian accidents is similar to that of other accident types; the effects for cyclists are somewhat smaller (10-20%). The meta-analysis showed an increase in the number of damage-only accidents at roundabouts.

Figure 4.6. **Roundabout in Chrudim (Czech Republic)**

Source: CDV.

Roundabouts with an outer diameter of between 30 and 50 meters, with one lane on the circle as well as on the entries and exits, are a very promising measure for increasing road safety, both in terms of efficiency on road safety as well as on the desired change of the speed. In the last decades, this type of roundabout has become more common at rural junctions.

Small roundabouts (with a diameter between 24 and 30 metres) have become increasingly popular in many countries at many junctions, where there is no possibility to build larger roundabouts, especially on urban access roads. The desired effect on the speed of through-going vehicles depends very much on the precise design and construction of each of the parameters of the mini roundabout, as well as the amount of traffic and the space available.

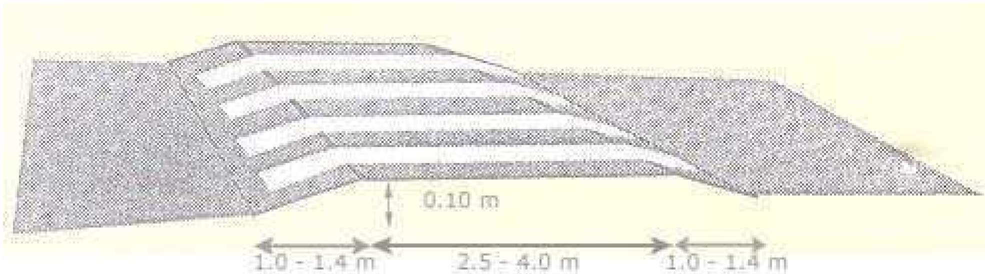
Mini roundabouts (diameter <24 metres) are not as well utilised around the world as small ones. There is insufficient data concerning their influence on speed, but they seem to be an appropriate type of intersection treatment in residential areas.

Speed humps

Speed humps are the most widely-used form of traffic calming, especially in those countries where traffic calming has spread very quickly: Great Britain and Netherlands. However, they are not so well favoured in countries where traffic calming was implemented later *e.g.* Austria, Czech Republic. Humps may be divided into different types depending on their design, starting from the thermoplastic versions and continuing up to raised junctions.

The effectiveness on desired speed is well proven; however it should be noted that speed humps generate higher levels of noise, which is a real nuisance for the people living nearby. The speed reduction effect – usually perceptible 50 meters before and after the humps – is largely dependent on the hump heights and gradients

Figure 4.7. **Hump at a pedestrian crossing** [15]



Source: CERTU.

In comparison to "simple" humps, raised pedestrian crossings and raised junctions are more and more popular, especially when part of a traffic calmed zone or a Zone 30 (see figure 4.7 and 4.8). In recent years whole raised sections of road may be seen, as a part of the new design of urban space – with or without physical separation of different traffic modes.

Figure 4.8. **Raised junction in Grenoble (France)**

Source: CERTU.

Cushions

An alternative solution to reducing speed is the use of cushions, which do not affect buses (in particular public transport buses) or trucks (see figure 4.9) since their track (*i.e.* the distance between their front wheels or their back wheels) is larger than the width of the cushion.

15. The figure dimensions are those recommended in France, but may differ from one country to another.

Figure 4. 9. **Cushion**

Source: CERTU

Temporary measures

For a variety of reasons, including budgetary constraints, the implementation of an improved road design can take time. It is therefore sometimes appropriate to implement temporary measures. This can be done with bollards and road marking (see figure 4.10).

Figure 4.10. **Temporary design in Belfort (France)**

Source: CETE, Lyon.

4.8. Future of infrastructure measures

Speed management through infrastructure changes has saved many lives. With the knowledge we have accrued about best practices, as well as lessons learned from mistakes, traffic calming will continue to be a very important speed management measure in urban areas. At the same time, it will be important to develop dynamic speed limits on all kinds of roads, in different traffic and for different weather conditions.

4.9. Implementation issues

There are a number of implementation issues associated with infrastructure measures. One of these is generally funding.

As more stakeholders become interested in infrastructure changes which can help the management of speed, it will become easier to secure funding. Already there is a lot of knowledge of best practices among the experts in road safety about this issue. A general lack of funding at any level does not mean that nothing should be done.

Dissemination of information to the various levels of decision makers, as well as among groups of stakeholders, including urban planners and designers, construction companies, road operators and police, is an essential step. Best practice can be identified as part of a Catalogue of ideas (Herrsted *et al*, 1993) but measures with less effective results should also be included so as to include all options. All professionals working in the field of road engineering need to be well trained and keep their knowledge of infrastructure improvements for speed management purposes up to date. All measures can have unforeseen impacts and implementation requires appropriate studies on the actual needs.

With the necessary training and the wider knowledge of best practices achieved via these different channels, it will be easier to secure support for the implementation of cost-effective infrastructure improvements and changes. Of course, the prospects will be enhanced with the help of other ministries and stakeholders from different sectors (Health, Social affairs, Environment, Regional or Spatial development etc.).

4.10. Policy considerations

The aim should be to produce safe, "self explaining" roads, where drivers recognise the type of road and are guided to adapt their speed to the local conditions.

To achieve this outcome, each road should have a clear function: access, distribution or flow. For each of these functions, there is a corresponding appropriate speed, which should be suggested by the infrastructure design.

Infrastructure improvements are often more cost effective and easier to implement in built-up areas, where immediate safety benefits can be made. In dwelling areas, near schools, at pedestrian crossings, *etc*. measures such as speed humps and road narrowings should be employed where speed reduction is required.

On rural roads, changes in infrastructure are more difficult to implement because of the extent of the network and the costs involved. Improvements can be made by removing roadside obstacles to make roads safer and more forgiving. While the ideal solution would be to separate traffic on rural roads (using median barriers for example), resource constraints generally prevent this being done widely but this measure could be considered in high risk locations. Alternative solutions to achieving speed reduction, such as the possible use of new technologies (*e.g.* ISA), should therefore be considered as well.

When the infrastructure cannot be upgraded, at reasonable costs, to the standard required for the existing speed limit, the appropriate action is to reduce the speed limit.

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CHAPTER 5.

SETTING SPEED LIMITS

This chapter outlines the basis for the assessment of appropriate speed limits. It reviews national speed limit regimes, including the underlying principles for defining general speed limits and local speed limits, and identifies the speed limits currently in force in OECD/ECMT countries. The chapter also considers innovative approaches to the implementation of speed limits (*e.g.* variable and dynamic limits) and outlines policy considerations related to setting speed limits.

5.1. Introduction

Once the appropriate speed has been determined for a road or a section of road — taking into account road safety requirements as well as mobility and environmental considerations and quality of life for the people living alongside the road – steps must be taken to ensure drivers adopt the appropriate speed. One of the key measures for achieving appropriate speed outcomes is the implementation of speed limits. Appropriate speed limits in themselves are only one element of a speed management approach, but for the foreseeable future speed limits will continue to form the backbone of speed management strategies and policies.

Speed limits act as a key source of information for road users. Set correctly, they help reinforce drivers' assessments of a safe speed and act as a pointer to the nature of the road and associated level of risk to both themselves and vulnerable road users. Speed limits are therefore an important part of the toolkit for achieving appropriate vehicle speeds and wider road safety benefits.

Most commonly, speed limits specify the maximum safe speed of travel permitted for light vehicles on a road under ideal conditions. Speed limits are not intended, however, to be seen by drivers as setting a target speed, nor as being appropriate in all conditions. Drivers should be encouraged to adopt lower speeds when required by the prevailing conditions. Additionally, local speed limits should not be set in isolation, but considered alongside other methods to manage speeds, including engineering measures, education, training, publicity and enforcement.

Speed limits are the means by which legal sanctions can be brought to bear on those who drive faster than is appropriate on the roads. Ideally, the road environment and the speed limit should be coherent and consistent so that most vehicles comply with the speed limit that has been set (see chapter 4, sections on self explaining roads).

5.2. How to define appropriate speed

The road network consists of a variety of different types of roads, from motorways for long distance inter urban travel, to arterials in urban areas and down to the small local roads in residential areas and city centres. A speed management policy must be based on an evaluation of what are the appropriate speeds on these different parts of the road network.

The appropriate speed for a section of road is set taking into account safety, mobility and environmental considerations and the impact of the chosen speed on the quality of life for the people living alongside the road. Appropriate speed differs from one type of road to another and recognises the different weight to be given to the various elements on the different parts of the road network.

From a safety perspective, the threshold of physical resistance of the human body to the energy released during an accident (which is related to the impact speed) is a critical input to the assessment of appropriate speed. For example, the World Health Organisation (WHO, 2004) has highlighted that pedestrians incur a risk of around 80% of being killed at an impact speed of 50 km/h, while this risk is reduced to 10% at a 30 km/h impact speed. This human impact factor suggests that in urban areas with a high concentration of pedestrian activities, the appropriate speed should be below 30 km/h.

The speed limit setting process should take into consideration elements such as road alignment and surface quality, as well as the number and location of people living along the road and the presence of pedestrians and other vulnerable road users. Appropriate speed limits should also take into consideration noise levels generated by traffic for people living in the surroundings.

There is no magical formula for defining appropriate speed on a given section of road, as it takes into account a wide variety of factors. Table 5.1 presents a summary of some of these considerations for different types of roads.

5.3. National speed limit regimes

A national (or state-wide) speed limit regime will normally consist of a limited number of general speed limits and a variety of local speed limits. When set according to the defined appropriate speeds, speed limits reflect safety requirements and mobility considerations, and, increasingly, environmental considerations. The overall speed limit framework, including the general limits for different road types, is usually defined within the legislative framework by national governments, whereas the exceptions to these general limits, *i.e.* the local speed limits, are often set by local governments.

General speed limits do not correspond to the appropriate speed on all roads or at all times because of the constantly changing roadway environment (such as curves) and local limits are required. In most countries, local and regional road authorities are responsible for determining speed limits on their roads to meet local needs and considerations. They sometimes allow for variable speed limits, whereby the limit is varied according to time of day (daytime, night-time) or time of the year (winter/summer). A further step is to introduce dynamic speed limits which take into account the actual traffic and/or weather conditions on the road (see also section 5.8).

Although most speed limits refer to maximum speeds, some minimum speed limits also exist, most notably on motorways, to reduce speed variability (see also section 5.10). Some countries also make use of “advisory” or “recommended” speeds, for example to warn of a hazardous curve, but such limits are by their nature difficult to enforce.

Even in the case of self-explaining roads (see chapter 4), there will be occasions when it is appropriate to have a lower speed limit on a stretch of road because of accident history. In these instances the increased risk to drivers and other road users could also be highlighted by warning signs.

Table 5.1. **Speed management: How to define appropriate speed for different types of roads**

Road category and function	Appropriate range of speed to meet specified objectives Safety	Environment	Economy and mobility	Quality of residential life
Motorways and principal inter-urban roads High quality network designed for high speed range for long distance movement of people, goods and services	**90 to 130 km/h**[1] Reduced speed may be appropriate in poor weather.	**70 – 90 km/h** Higher speeds lead to high emissions and noise. Reduced speeds needed where air quality or noise issues are important.	**High end of speed range** This is of high importance for commercial and private movements alike.	**Low end of speed range** Little adjacent development but, where there is, speeds should reflect this to improve noise, air quality and severance.
Urban arterial roads and main roads High quality urban network designed to cater to through traffic	**50-60-70 km/h** Reduced to 30 km/h where there are many vulnerable road users.	**30 – 60 km/h** Within optimum range for vehicle emissions.	**High end of speed range** Local traffic as well as through traffic. Often commercial and residential development. Need to balance safety and mobility.	**Low end of speed range** Important where adjacent land use is residential. Need to manage speeds for air quality, noise and severance effect.
Urban residential roads Network designed for living and access only for local traffic.	**30 km/h** Traffic calmed where necessary to achieve lower speeds.	**?**[2] Below optimal range for emissions, vertical traffic calming elements can cause increase in noise.	Takes second place to safety and quality of life.	Very important on all residential roads.
Rural main roads (not principal inter-urban) Designed for local through traffic.	**70 to 90 km/h** Depending on quality[3]. Reduce for curves and junctions.	**60 to 90 km/h** Lower speeds within optimum range for emissions but higher speeds lead to more emissions and noise.	Important.	
Minor rural roads Designed for local access traffic with presence of vulnerable road users.	**40 to 60 km/h** Depending on quality and presence of vulnerable road users.	Within range of optimum speeds.	Takes second place to quality of life.	

1. Some jurisdictions have higher speed limits on part of this network.
2. There is not enough research results to decide on this.
3. The poorer the road in terms of bends and junctions the lower the speed.

Box 5.1. **Norwegian experience in evaluating appropriate speeds**

In 2000, Norway attempted to evaluate appropriate speeds on various types of roads in built-up areas, to assist the Public Roads Administration in defining a new policy for setting speed limits in urban areas. Appropriate speeds on the different types of roads were assessed on the basis of the following "cost" elements:

- Time costs for all road users
- Operating costs for motor vehicles
- Accident costs
- Costs related to the feeling of danger
- Costs related to noise from motor traffic
- Costs related to local and global pollution

On the basis of these elements the following appropriate speeds were defined:

- Regional main roads: 60km/h
- Local main roads: 50 km/h
- Distributor roads: 50 km/h
- Access roads: 30 km/h
- Roads in city centres: 30 km/h

These figures are calculated from a scientific base. It is then up to the politicians or, in the case of Norway, to the Public Roads Administration, to define speed limits on the basis of these calculations.

Source: Norwegian Public Roads Administration

5.4. Underlying principles for defining general speed limits

A number of criteria are normally used in the different countries for defining general speed limits. Some of these criteria are listed below and are further discussed elsewhere in this chapter:

- Type (category) of road/street/environment (*e.g.* 110-130 km/h on motorways, 70-90 km/h on rural roads and 50 km/h in urban areas).
- Type of vehicle or type of loads (specific speed limits for heavy vehicles, public transport vehicles, farm vehicles, transport of dangerous goods, etc.).
- Type of tyres (specific speed limits for studded tires).
- Type of drivers (specific speed limits for young or novice drivers).
- Weather conditions (specific speed limits in case of rain, fog, etc.).

At present, there is diversity across OECD/ECMT countries in speed limits set for roads with specified functions. Table 5.2 shows the general speed limits for the countries that responded to the OECD/ECMT survey (more details can be found in Annex B). The current general speed limits vary across the world, but most countries follow a hierarchical approach and adopt speed limits within the following levels:

- Urban roads: 30–50 km/h
- Main highways or rural roads 70–100 km/h
- Motorways 90–130 km/h

Table 5.2. ***General* Speed Limits for passenger cars in a selection of OECD/ECMT countries in 2005**

	Motorways	**Main highways and rural roads**	**Urban roads (local and collector street) (urban arterials not included in this table, see Annex B)**
Australia (Victoria)	100-110 km/h	100 km/h	50 km/h
Austria	130 km/h	100 km/h	50 km/h 30 km/h zones 40 km/h streets in residential areas
Canada	100-110 km/h	80 to 100 km/h (main) 70 to 100 km/h (rural paved roads)	40-50 km/h
Czech Republic	130 km/h	90 km/h	50 km/h
Denmark	130 km/h	80 km/h	50 km/h
Finland	120 km/h	100 km/h (main) 80 km/h (rural	30-40-50 km/h
France	130 km/h	90km/h	30 or 50 km/h
Germany	None 130 km/h is recommended	100 km/h	50 km/h
Greece	120 km/h	110 km/h (main) 70-100 km/h (rural)	30 km/h (local streets) 40-50 km/h (collector streets)
Iceland	90 km/h	80 km/h / 90 km/h (gravel roads/paved roads)	30 km/h (local streets) 50 km/h (collector streets)
Ireland	120 km/h	100 km/h (national roads) 80 km/h non urban regional roads	50 km/h
Japan	100 km/h (national expressways)	40-50-60 km/h (national highways)	
Korea	90 -100 - 110 km/h	60 km/h (2x1 lane) 80 km/h (2x2 lanes or more)	60 km/h (2x1 lane) 80 km/h (2x2 lanes)
Mexico	130 km/h	110 km/h (main) 100 km/h (rural)	20-60 km/h
Netherlands	100 or120 km/h	100 km/h (main) 80 km/h (rural)	50 km/h
Norway	90 or 100 km/h	80 km/h	30-50 km/h
Poland	130 km/h	100 km/h (main) 80 km/h (rural)	50 km/h
Portugal	120 km/h	90-100 km/h	50 km/h
Russia	110 km/h	90 km/h	60 km/h
Sweden	110 km/h	90 km/h (main) 70 km/h (rural)	50 km/h
Switzerland	120 km/h	80 km/h	50 km/h
United Kingdom	70 mph (113 km/h)	60 mph (97 km/h)	20-30 mph (32-48 km/h)
United States (Varies by state)	Urban: 55-70 mph (88-113 km/h) Rural: 65-75 mph (104-120km/h)	55-70 mph (88 -113 km/h)	25-35 mph (40 -56 km/h)

Note: Figures in the table presents the *general* speed limits. Please refer to the Annex B for specific conditions and comments.

Speed limits for different road types

An effective speed limit regime requires nationwide consistency. Some administrations help achieve this by adopting speed limit hierarchies based upon road function (Wegman *et al.,* 2006). The principle behind this is that higher speed limits are expected on principal roads (motorways and other interurban roads) for long distance travels than for distributor roads. Lower speed limits are expected on residential streets or local access roads where the risk to vulnerable road users is much higher and more frequent.

Vision Zero in Sweden and Sustainable Safety in the Netherlands provide examples of speed management strategies based on the development of a hierarchy of roads for speed management and traffic safety purposes. Vision Zero, as developed in Sweden, brings a human impact focus to the determination of speed limits on road networks, reflected by the finding that pedestrians and other vulnerable road users are unlikely to survive if hit by a car going faster than 30 km/h (see figure 2.6 in chapter 2). This led to the conclusion that on roads where there is a mixture of cars and pedestrians, the speed limit should be 30 km/h. A further finding is that, in a modern car, a car occupant will survive a side impact at not more than 50 km/h. This led to the conclusion that speed limits at intersections, where side impacts are a risk, should not exceed 50 km/h. As well, in a modern car, a car occupant will not survive a frontal shock with a similar car if the speed of the vehicles exceeds 70 km/h. Therefore, ideally, the speed level should not be higher than 70 km/h on roads where there is a risk of frontal crashes. Where higher speeds are desired, a median barrier should be in place. More details on Vision Zero, Sustainable Safety and other national road safety strategies are given in Annex A.

A hierarchical approach can be integrated into wider planning processes to help reduce urban sprawl and create safer urban and rural environments. The overall objective is to ensure that the "right" traffic travels on the "right" road at the "right" speeds.

Finally, it should be noted that harmonising speed limits across Europe (or other regions) for roads with the same hierarchical function would increase their credibility among the general public. In addition, the decision of any country to change its speed limits (increase or decrease) may have a significant influence on its neighbouring countries. Wide divergences bring the credibility of the speed limits across the region into question by the general public. Therefore any decision to adopt divergent speed limits should give due consideration to the important potential impacts.

Urban roads

Urban roads are by their very nature complex, given their need to provide for safe travel on foot, bicycle and motorised vehicle. Lower speeds benefit the safety of all road users and reducing inappropriate speeds is therefore an important factor in improving urban safety. Many urban casualties occur on residential streets and involve a high proportion of pedestrians, cyclists and children. It is therefore common practice to discourage through traffic from using residential streets and to manage the speed of traffic requiring access to such streets using traffic calming and associated techniques as set out in chapter 4. It is also common practice to set a 30 km/h limit on residential roads or in areas where children are at particular risk. Research shows that these lower limits, when accompanied by traffic calming measures, are very effective in reducing accidents and injuries (reductions of up to two thirds have been demonstrated *e.g.* by TRL).

Roads in city centres are often characterised by high accident risk per km driven, partly because of the mix of road users. Consequently it has become increasingly common to use 30 km/h speed limits on such roads (for instance in Graz in Austria). This measure is also in accordance with the Norwegian assessment of appropriate speed shown above (Box 5.1).

In summary, in urban areas, taking into account the impact tolerance of the human body, the speed limit should not exceed 50 km/h – and 30 km/h zones are recommended in areas where vulnerable road users are particularly at risk, as they have proven very effective in reducing accident risk and severity and protecting vulnerable road users.

Rural roads

Many fatalities occur on rural roads where inappropriate speed can be particularly hazardous, given the geometric characteristics of narrow roads, hills, curves and intersections. Some countries use speed limits to offset such dangers on the road network, whereas others use danger warning signs, sometimes combined with an advisory speed.

On rural roads, speed limits usually vary from 70 to 100 km/h in OECD/ECMT countries. Given the diversity of roads, it is not possible to recommend an ideal limit. What is important is that the limits be set in accordance with the design standard of the roads. When the infrastructure cannot be upgraded at reasonable costs to the standard required for the existing speed limit, the appropriate action is to lower the speed limit.

Motorways

Despite greater speeds, motorways are generally the safest roads, due to their higher design standards. Most countries' interurban motorways have a speed limit of 120-130 km/h. While there is no legally enforced speed limit on approximately one third of German motorway networks, the recommended top speed is 130 km/h. Furthermore, in the event of an accident on such roads in Germany, the driver is automatically held responsible if it is proven that he or she was travelling at above 130 km/h.

Speed limits must be credible given the characteristics of the roadway and the surrounding environment. For example, there should be a clear difference between speed limits on motorways and other roads in order to maintain the attractiveness of the motorway, which is the safest road category.

Specific case of transition zones

Studies on the effect of infrastructure characteristics on speed selection show that drivers make larger speed adjustments where the transitional situation is clearly functional – where the need to adjust the speed of their vehicle is sufficiently “obvious” to them. Formal notification of a transitional situation (by signing only) is not sufficient to induce appropriate speed behaviour if it does not correspond to the way in which the driver perceives and categorises the situation. Obvious discrepancies between the structural elements of the road environment and the posted speed limits reinforce inappropriate driving behaviour. These findings concur with those observed in other transitional situations, such as road intersections (Monseur and Marchadier, 1971; Saad *et al*. 1990). It is important for road designers to either visually highlight the transitional situation (*e.g.* with gates, as per chapter 4), or incorporate structural constraints that clearly identify it as a functional change. In transition zones, it is common practice in many countries to decrease (or increase) speed limits in 20 km/h increments. For example, when drivers go from a motorway where the speed limit is 120 to a petrol station or a lower class road, there should be a gradual decrease of the speed limit (100, 80, 60, etc.).

Different speed limits for different types of vehicle

The vehicle category mix and speed differentials have an impact on safety. As well as encouraging Heavy Goods Vehicles (HGVs) to use designated roads, such as motorways or designated lanes, EU countries generally apply a lower speed limit for HGVs and buses/coaches on most rural roads.

The majority of countries apply an overall maximum speed limit for HGVs (often 80 km/h) and buses (varying between 80 and 100 km/h). By EU-Directive 92/24/EEC and its recent adaptation (2004/11/EEC), speed limiters are compulsory for HGVs of more than 3.5 tonnes and for vehicles of more than 9 seats. Some countries have, however, taken further steps to apply lower HGV and bus speed limits for different road types, *e.g.* Denmark, Ireland and the United Kingdom (see table 5.3). In North America (Canada and the United States), there are rarely differentiated speed limits for trucks. Some countries have differentiated speed limits for caravans.

Table 5.3. **Speed limits in the United Kingdom for different types of vehicles**

	Built-up area	Single carriageways	Dual carriageways	Motorways
Cars and motorcycles	30 mph (48 km/h)	60 mph (96 km/h)	70 mph (112 km/h)	70 mph (112 km/h)
Cars towing caravans or trailers	30 mph (48 km/h)	50 mph (80 km/h)	60 mph (96 km/h)	60 mph (96 km/h)
Buses and coaches (not exceeding 12 m in overall length)	30 mph (48 km/h)	50 mph (80 km/h)	60 mph (96 km/h)	70 mph (112 km/h)
Goods vehicles (not exceeding 7.5 tonnes maximum laden weight)	30 mph (48 km/h)	50 mph (80 km/h)	60 mph (96 km/h)	70 mph * 60 if articulated or towing a trailer (112 km/h)
Goods vehicles (exceeding 7.5 tonnes laden weight)	30 mph (48 km/h)	40 mph (64 km/h)	50 mph (80 km/h)	60 mph (96 km/h)

Some countries (*e.g.* Italy) have experience with differentiated speed limits based on the displacement (or power) of the engine. Such a practice can only lead to a greater heterogeneity of speeds and cannot be recommended.

5.5. Underlying principles for setting local speed limits

If roads were presented in ways that drivers immediately chose a speed close to the appropriate speed, there would be no need for local speed limits. However, for the foreseeable future there will always be situations where there is a discrepancy between drivers' perceptions of a safe speed, based on messages from the road environment - and the appropriate speed, as established by analysis. Local speed limits can deal with such exceptions to the general speed limits. Individual drivers' responses to a given level of risk vary as does accident risk along any section of road. Studies have consistently shown that many drivers tend to underestimate the actual risk of travelling at a particular speed. Therefore, it is highly unlikely that reliance solely on drivers' responses to the environment will produce acceptably low risk travel speeds.

Accidents and injuries should be a key factor in determining accident risk and therefore whether a local speed limit is needed. Local speed limits will be especially necessary if there is a long history of accidents or there are other substantial risk factors, even if not yet manifesting themselves as accidents.

One approach that has been in use for several decades is to start with the prevailing speed of traffic as the first approximation of the level to use in setting the speed limit, and then use appropriate modifications to this value as needed. The speed below which 85% of drivers in free flow conditions travel (also called the V85 or 85^{th} percentile speed) has historically been used as the first step in determining the maximum reasonable and safe speed. This method was applied when introducing the first speed limits on the premise that the vast majority of drivers would travel at appropriate speeds. This approach is increasingly considered as no longer appropriate for today's road environment now that the substantial increases in risk associated with small increments in travel speeds by a majority of road users are better understood.

Emerging approaches to speed limit setting include:

- Assessing the combined risk of the interaction of the infrastructure, the travel speeds (based on possible speed limits) and the volume and mix of traffic and pedestrians (using accident history as a key input); and adopting a speed limit to achieve a combined risk at least below average risk levels for comparable sections of the network; or

- Utilising a safe system approach, requiring targeted infrastructure safety investments and speed limits which in combination will avoid fatal energy transfers in accidents.

A number of countries which have not adopted these approaches are using the mean or the median free speed of traffic along a length of road as the basis for the speed limit. For example, the recommended practice in the United States is that speed limits not be set below the 50^{th} percentile speed. Great Britain, in its new guidance on setting local speed limits published in August 2006 (DfT, 2006), has moved to mean speeds as one of the determining factors when setting speed limits. While these are thought to better balance the speed at which the majority of drivers travel with the needs of other road users or local communities – yet still be an appropriate speed to the majority of drivers – they are not determined on a risk basis and also assume that drivers have good knowledge of risk at selected travel speeds, which is not necessarily the case.

As indicated earlier, it is unrealistic to expect drivers to take all the above elements into account. The speed limit, therefore, should not be a desired speed as expressed by drivers. Instead, it is recommended that the local speed limits are set at an appropriate speed which is based on achieving lower than average accident risk (a definition of safe travel).

Adopted speed limits should maximise access and facilitate sustainable mobility consistent with safe travel, quality of life and environmental costs. While trade-offs between these factors can be assessed from a quantitative point of view, it is unacceptable to use the benefit of aggregation of thousands of very small trip time savings as an offset for actual human impact and accident trauma. The time savings are not a transferable benefit and these types of offsets have long been considered unacceptable, for example, in work place safety practice.

Different countries have different ways of defining appropriate speed (and hence speed limits) on their road networks. Whatever the method chosen, it is preferable to use a "rounded" number for the speed limit, such as 40, 50, 60 km/h (at least for the countries using the metric system). Some countries use "odd" limits (30, 50, 70 km/h, etc.). Given the large variety of road networks, it would be advisable to use the full range of speed limits (30, 40, 50, 60 km/h, etc.) to more closely align speeds with road safety. Most countries set a minimum distance over which local speed limits are applied – for instance not less than 600 metres – and encourage reasonable consistency of limits over a length of a route. Adequate, consistent speed limit signage is critically important to maintain awareness of the limit and the public support for its application and enforcement (see also chapter 6 on Signing).

It is important to review existing speed limits to ensure their consistency with the local environments and to increase their credibility. The review should take into consideration factors such as the road function, the road geometry, the level of adjacent development and the presence of vulnerable road users.

Use of models (LIMITS Programmes)

Several models have been developed to assess the most appropriate speed limits, from a road safety point of view, based on a variety of factors. The most widespread models are the LIMITS programmes.

The LIMITS programme is a computer-based programme for assessing speed limits. It consists of a number of decision trees which are used to evaluate a series of road, vehicle and driver parameters which, when applied, contribute to the creation and operation of a safe road system that takes into account community mobility. It does not however include factors such as the environment, the quality of life, etc.

Based on the LIMITS programme, several models have been developed for application in New Zealand (NZLIMITS), United States (USLIMITS) and Australia (QLIMITS, NLIMITS, VLIMITS…). All take into account the following factors:

- The road and its road environment (road function, number of lanes, alignment, etc.).
- Abutting development (presence of schools, residential areas, etc.).
- The nature and level of road user activity (pedestrian, cyclist, heavy vehicles, etc.).
- Accident record.
- Speed limit on adjacent sections.

The programme user enters information that describes a road – both objectively and subjectively – and then the program employs a decision tree to calculate the recommended speed limit. A key objective and outcome of the expert system, XLIMITS, is that it reduces the subjectivity for decisions on speed zoning and increases the level of consistency in the zoning of similar roads, zoned by different people in different parts of a state.

Models such as LIMITS that assist in setting speed limits are useful in that they can help ensure a more consistent application of speed limits across a jurisdiction and ensure that a similar weighting is given to the various factors that influence speed limits.

However, such models also have some limitations. The speed limit recommended by the model is a starting point which may then need to be adjusted based on the specifics of the combination of factors or other factors which cannot all be modelled. The current version of VLIMITS (used in Victoria, Australia) for instance does not take into account the accident rate of the road to determine the speed limit. Instead it highlights when a road has a high accident rate and then allows the user to consider whether the speed limit should be further adjusted from that recommended by the model - this is clearly a major deficiency. In addition, any model requires updating if speed limit policy is updated; otherwise it will become out-of-date. Most current models are not based on a detailed risk assessment approach. Some aspects of this approach (such as the use of “school zones” and the consideration of accident rates) can be incorporated into existing models. However once further research on the relationship between speed, road features and accident risk is carried out and accepted more widely it is likely that speed management principles and the associated speed setting models will be developed to reflect this more complex and risk sensitive approach. In addition, the speed limits recommended by the model only take into account road safety aspects and do not consider all the elements described in chapter 2.

5.6. Variable and dynamic speed limits

An increasing number of countries now implement variable and dynamic speed limits, whereby the limit is varied according to the time of day (daytime, night-time), the season (winter/summer), or takes into account the actual traffic conditions (*e.g.* weather) on the road.

There are two categories of speed limit that vary according to certain criteria:

- **Variable speed limit**s are activated through general criteria, such as the time of day, season, certain weather conditions (rain/wet). These limits are usually set by each country at the national level. These are usually conveyed by fixed signing or through the Highway Code.

  – A few countries apply lower general speed limits for bad weather conditions. For example, in France, in case of rain or snow, the speed limit for motorways changes from 130 km/h to 110 km/h and on rural roads from 90 km/h to 80 km/h. In case of fog (visibility less than 50 meters), forward vision is reduced so reduced speed limits are particularly important. The speed limit on all types of roads is 50 km/h (see figure 5.1) under fog conditions.

  – Both Finland and Sweden apply different general speed limits in wintertime. In Finland, the speed limit on motorways changes from 120 km/h to 100 km/h and, on main rural roads, from 100 km/h to 80 km/h. These changes have been positively evaluated by Peltola (2000). Similarly, in Sweden the speed limits change respectively from 110 km/h to 90 km/h and from 90 km/h to 70 km/h.

  – In the United States, Norway, Australia and several other countries, variable speed limits are applied in school zones at entering or exiting times.

Figure 5.1. **National (general) speed limits in France (in km/h)**

	Built-up areas	Roads	2x2 lane roads	Motorways
General limits	50	90	110	130
Rain	50	80	100	110
Young drivers (<2 years)	50	80	100	110
Poor visibility (<50 m)	50	50	50	50

Source: French Ministry of Transport

- **Dynamic speed limits** are generally activated at a given time, based on traffic volume or other criteria.

  – In France, it is common to reduce the speed limit by 20 km/h on a temporary basis to improve air quality. This happens when the level of pollution is elevated due to high temperatures. The speed limit is then displayed either by variable message signs or announced through the media, but on these occasions the speed limit is not easily enforced, due to the fact that fixed speed limit signs remain visible.

  – Dynamic speed limits are also used for speed control / regulation. When traffic flow and vehicle density increases, inter-vehicle time and distance decreases. In this event, the proposed speed (speed limit or recommended speed) needs to decrease to be compatible with the safe stopping of the vehicle (*i.e.* reasonable braking distance).

  – In some countries (*e.g.* Germany, United Kingdom) matrix signs on motorways provide advisory or compulsory reduced speed limits when weather conditions are bad.

  – Observations of traffic flows show that when traffic increases and nears maximum capacity, the flow is disturbed and the risk of accident increases. Usually, in these circumstances, a decrease in travel speed can lead to flow stability and a capacity gain (of at least a few percent) as well as a safety gain.

  – Lowering the speed limit can also lead to a reduction of differences in speed between consecutive vehicles driving on the same lane, which in turn leads to a decrease in the risk of rear end collision. It also decreases the speed of the flow in the fast lane, and thus leads to a reduced interest in changing from the slow to the fast lane, which is potentially dangerous.

  – Applying the same speed limit for all lanes emphasises this benefit. This option is used in many countries. However, in some countries (Italy, Luxembourg, etc.) it is possible to apply different speed limits for different lanes.

Figure 5.2. **Dynamic speed limit in Switzerland**

Source: ARG Lausanne

– Dynamic *advisory* speed limits have also been introduced in and near some cities (*e.g.* near Strasbourg, France) (figure 5.3).

Figure 5.3. **Advisory speed sign**

Source: SANEF

Box 5.2. **Experiment in "speed management" by variable speed limits on the A7 motorway in France**

ASF (Autoroute du Sud de la France – the company managing a French motorway network) conducted experiments, during the summer of 2004, with an innovative traffic control system on the A7 motorway, one of Europe's busiest interurban routes.

On this north/south corridor linking northern France with Spain and Portugal as well as the Riviera, traffic flows increase during the holiday period from a daily average of 75 000 vehicles to around 110 000 vehicles. During the Summer of 2004, ASF tested a new traffic management system to control speed, based on a range of ITS technologies.

An algorithm was designed to give advance warnings of congestion based on historical traffic flow data obtained from inductive loops buried in the carriageway. When the algorithm detects an anticipated risk of "traffic flow destabilisation", an alarm signal is transferred in real time to the control centres, where traffic operators check the validity of the signal and activate the system to inform the road users of the traffic conditions.

Road users are informed in real time of the current speed limit through motorway information being broadcast via radio (on stations designated for traffic information purpose), by mandatory speed limit pictograms (70, 90 or 110 km/h) mounted on overhead gantries, and with Variable Message Signs (VMS) located every 10 km. (see figure 5.4).

At the same time, the average speed of vehicles is calculated. If the calculated speed is higher than the current mandatory limit on the section, a VMS displays the vehicle's licence plate number and warns the driver to slow down.

Initial evaluations showed that 75% of drivers drove within the speed limits. Roadside surveys also suggested that the system is widely supported by the motorists who faced less congestion and fewer accidents during their journey. Ongoing statistical studies seem to indicate favourable trends in terms of traffic capacity and delay in the occurrence of congestion.

Source: Schwab (2005), Autoroutes du Sud de la France.

Figure 5.4. **Variable speed limits on the A7 motorway (France)**

(Fort trafic, vitesse limitée = Heavy traffic. Speed limit is reduced.)

Source: ASF

So far, the cost of the associated infrastructure has made it difficult to provide a positive business case for implementation of variable and dynamic speed limits in non-motorway situations. In Sweden[4], a three-year "Variable speed limit trial" is currently underway to test higher speeds on some roads/junctions. The overall aim of the project is to verify if there is a higher acceptance of dynamic speed limits. This project involves varying the speed limit, using automatic or manual control, between 30 and 120 km/h to reflect weather conditions, traffic conditions/congestion, pedestrians, buses and vehicles in junctions.

5.7. Impact of changes in speed limits on speed and accidents

As seen in Chapter 3, a considerable proportion of vehicles are driving at excessive speed, *i.e.* (above the speed limit). It could therefore be concluded that the speed limit influences speed to only a limited degree. However, a considerable amount of research has been undertaken to assess the effect of changes in speed limits, and this has shown that a speed limit does have a clear influence on actual speeds. Meta-analyses show that lowering the limit by 10 km/h leads to a decrease in speed of 3-4 km/h. A similar effect can be expected from an increase in the speed limit. This has been confirmed by research carried out on recent changes in speed limits in the United States (Cohen *et al.,* 1998) and also in Switzerland, Hungary and Norway (Le Breton, 2005, Hollo, 1999 and 2005).

When, for example, the speed limit is lowered from 80 to 70 km/h, without changing the road infrastructure, it leads to a decrease in speed of some 5 % (3-4 km/h) (Ragnøy, 2004). There is also a clear relationship between the speed and the level of accidents, as indicated by the Power Model (see chapter 2). From this model it can be expected that if the average speed level on a given road decreases by 5 %, then the number of injuries is reduced by 10 %, and the number of fatalities reduced by 20 %. Box 5.1. illustrates the experience of Hungary with both a decrease in speed limit (inside built-up areas) and an increase in speed limit (outside built-up areas). In both cases, data suggest a change in the number of fatalities in accordance with the Power Model.

However, it should be stressed that changing the speed limit alone has little effect. In places where speed limits have been changed and no other action taken, the change in average speed is only about one quarter of the change of the speed limit (DETR, 2000). Any changes in speed limits must be accompanied by appropriate enforcement, infrastructure and information measures. Reducing speed limits, without modifying road designs, or without permanent enforcement efforts, does not slow down the traffic by the same amount.

4. See also http://www.vv.se/vag_traf/variabla_hast/variable_speed_limit.pdf.

Box 5.3. **Experience in Hungary with changes in speed limits**

1. Decrease of the speed limit from 60 km/h to 50 km/h inside built-up areas in 1993

The decrease from 60 km/h to 50 km/h of the speed limit inside built up areas – in agreement with international experiences – proved to be an efficient road safety measure in Hungary, too.

The decrease from 60 km/h to 50 km/h of the speed limit in force inside built up areas resulted in a reduction of 18.2% in accident fatalities. However, by 1995 the accident data and results of speed measurements showed that the initial effect of the 50 km/h speed limitation was "fading away" gradually, and speed, as well as the number of fatalities inside built up areas increased again. This called for continuous efforts in enforcement inside built-up areas. Figure 5.5 shows a sharp decrease in road fatalities in 1993, for which change in speed limit was a main contributor. The good results shown in the figure are also due to intensive information campaign, intense police enforcement and other measures

2. Increase of the speed limits by 10 km/h outside built-up areas, May 2001

The speed limits on all road categories outside built up areas were increased by 10 km/h as of 1st May 2001. In particular the:

- General speed limit outside built up areas changed from 80 km/h to 90 km/h;
- Speed limit on highways increased from 100 km/h to 110 km/h;
- Speed limit on motorways increased from 120 km/h to 130 km/h.

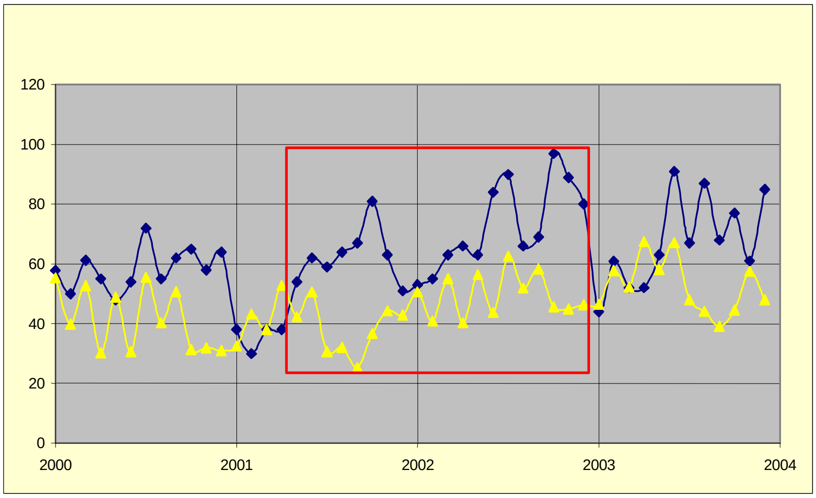
The safety level on roads outside built up areas, and in particular on first category main roads, deteriorated spectacularly following these increases. The number of fatal victims outside built up areas increased considerably.

The use of the ARIMA model shows a firm deviation from the tendency as of May 2001, when the new speed limit outside built-up areas came into force (Figure 5.6).

Figure 5.5. **Number of road accident fatalities inside and outside built-up areas in Hungary between 1980 and 2003**

Source: Hollo

Figure 5.6. **ARIMA model – Tendencies taking a rising turn - Hungary**
Number of fatal accidents



Source: Hollo and Zsigmond (2004)

5.8. Administrative issues

Speed limits setting and signing raise several administrative issues, which need to be addressed by each country. These include:

- Which authority decides speed limits, depending on the road category?
- Is enforcement possible when speeds limits are displayed on variable message signs, and, if so, under what conditions?
- How should a slow moving vehicle be defined? Some countries have accurate definitions, while some countries (*e.g.* Switzerland) have a more flexible definition.
- What should the speed limit be in a slow-moving traffic lane?
- Are there minimum speeds?

In relation to the last point, several studies (Hauer, 1971; West and Dunn, 1971) showed that the presence of a significant number of slow vehicles in the traffic stream increases speed variability and the number of accidents. For these reasons, in France, for instance, vehicles that cannot reach 40 km/h on a constant basis are not allowed on motorways. Also in France, the minimum speed on the rapid lane of a 2x3-lane motorway – when there is no congestion – is 80 km/h.

5.9. Policy considerations

Speed limits are a key source of information to road users and well as the basis for enforcement. Therefore they have a fundamental role in overall speed management policies.

The assessment of appropriate speed and consequently the speed limit should be based on safety and also mobility and environmental considerations. It should take into consideration, especially in urban areas, the physical resistance of a human body. Research has shown that it is improbable that a pedestrian or other vulnerable road user would survive if hit by a car with an impact speed above 50 km/h. In urban areas, speed limits should therefore not exceed 50 km/h - with 30 km/h zones promoted in areas where vulnerable road users (including children) are particularly at risk.

It is recommended that appropriate speeds for all types of roads be assessed and existing speed limits reviewed taking into account the following key factors: road function, road geometry, level of adjacent development and the presence of vulnerable road users, as well as environmental emissions, noise and the quality of life.

Speed limits should seek to take into account the needs of all road users. This is partly a political question and thus the result of such consideration can vary to some degree from one country to another. For example, the value of life and the value of mobility are given different weights in different countries/states and hence lead to different speed limits for the same type of roads. Such variations are not well understood by the general public and may lead to a lack of credibility for the different speed limits. Therefore, harmonising speed limits across regions (*e.g.* Europe) is recommended to increase their credibility among the general public.

Several countries have lower speed limits for heavy vehicles, which are fully justified by their higher mass – and associated risk of causing severe injury – and the longer braking distances which they require. Given the extent of international movement of road transport vehicles in some regions, speed limits for trucks should desirably be agreed at international (regional) level. A harmonised 80 km/h speed limit for heavy vehicles could in particular be envisaged in Europe.

Local speed limits have often been set using the 85th percentile approach. This approach is increasingly considered as no longer appropriate for today's road environment now that the substantial increases in risk associated with small increments in travel speeds by a majority of road users are better understood. Some countries are using the mean speed of traffic as the basis for the local speed limits. However, while this approach better balances the speed at which the majority of drivers travel with the needs of other users, it does not take into account the actual level of risk. Emerging approaches to speed limit setting include assessing the combined risk of the interaction of the infrastructure, the travel speeds and the volume and mix of traffic and pedestrians. It is recommended that local speed limits be set based on achieving lower than average accident risk.

Ideally, there should not be any discrepancy between the road environment and the speed limit. In the case of such a discrepancy, it should be reduced to a minimum, either by modifying the road environment or by changing the speed limit. In most cases, for good reasons, the authorities will want to apply a relatively low speed limit on a road that, to the drivers, might seem to be able to support a higher speed. If the reasons for the low speed limit are sound, such as the involvement of vulnerable road users, the road environment should also be modified. If this is not possible in the short term, speed reducing elements should be introduced.

Speed limits must be credible in light of the road and road environment characteristics. For example, there should be a clear difference between speed limits on motorways and other roads in order to maintain the attractiveness of the motorway, which is the safest road category. At the same time, it is not advisable to set the speed limit too high on motorways, as this would lead to an increase in accidents as well as increase the adverse environmental impacts and energy consumption. On the other hand, there are many examples of unnecessarily low speed limits (*e.g.* 50 km/h) on roads such as dual carriageways with median barriers.

Ideally, all speed limits should be variable, in order to take into account the actual condition of the road, traffic and the weather. This is not yet possible, however, for cost and other reasons, but should be encouraged where possible. For example, variable speed limits are a very good solution near schools, and are already applied in some countries; however responsibilities must be clearly defined before implementation. Furthermore, the problem of enforcement of variable speed limits must be addressed.

While the general speed limit framework is best set by the government, it is important that within this framework, local authorities have the flexibility to set local speed limits that meet local needs and considerations. Local speed limits should not, however, be set in isolation, but as part of a package with other measures to manage speeds.

Finally, it should be kept in mind that speed limits, while important, are only one tool that can contribute to managing the problem of speeding. Speed limits cannot be considered as a stand-alone measure that by themselves can solve the problem of excessive speed. Reducing speed limits, without modifying road designs, or without permanent enforcement efforts, is not likely to reduce traffic speeds to the new lower limit.

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CHAPTER 6

SIGNS, SIGNALS AND MARKINGS

This chapter describes the various methods available to inform drivers of speed limits, whether fixed or variable. They include the various signs used to inform the drivers about speed limits, road markings and signals, including moderating green waves. They also include other tools used to communicate with drivers. The chapter concludes with policy considerations related to the implementation of a consistent policy for signs, signals and markings.

6.1. Signs

Generalities

General national speed limits are mainly communicated to drivers during the phases of driver training and licensing and they are then reinforced by information campaigns and signs on the road. They are also communicated to visitors through signs located at the point of entrance (*e.g*. borders, ports, airports). However, there are exceptions as well as circumstances which make it necessary to consult current driving regulations to know the specificities of the limits.

Some countries have introduced specific rules regarding speed limits which are related to weather conditions or pollution. These rules can be communicated to the public at large by means other than road signs (see section 6.6).

Time-specific or location-specific speed limits are indicated by signs located in the immediate vicinity of the points where the limit begins. They may also be placed to provide advance notice, with an additional panel.

Traffic signs must conform to those defined in the Vienna Convention[1], at least for the countries which have signed this document (United Nations, 1968 and 2004).

Figure 6.1. shows signs related to speed limits which are approved by the Vienna Convention.

Usually, the speed limits apply to all vehicles. However, in certain circumstances, it is useful to have speed limits which depend on the category of vehicle. In the latter case, it is important that all road users understand correctly the limits which concern them (*e.g*. where limits differ depending on the type of vehicle, heavy goods vehicles, for example).

Figure 6.1. **Speed limit signs of the Vienna Convention**

- Fixed prohibitory or restrictive signs (including entry zone signs).

- Informative signs (used in some rare cases, fixed signs for advisory speed).

- Mandatory signs for minimum speeds (used in some very rare cases on motorways).

- Variable message signs (located at fixed points or on special road sign vehicles).

- End–of-limit signs

1. The UN's Vienna Convention on Road Traffic ratified in 1968, and revised in 1995, standardises driving regulating among the 35 contracting parties.

Recommendations for the implementation of signs

Contrary to popular belief, developing a sound road signing practice is not an easy task, as certain principles must be respected:

- General principles (for all signs): uniformity, consistency, simplicity, relevance, concentration/legibility.

  For speed limit panels, one should use the right type of panel, always place it in the same manner, and limit as far as possible the number of signs.

  Furthermore, where it is necessary for several signs to be seen simultaneously (*e.g.* speed limit and bend), they should be installed in such a way that the user can see them at a glance, both during the day and at night.

- Other principles that must be fulfilled include:

  - Consistency between road design and signing: Signing should be consistent with both the road itself and the overall environment of the road.

  - Consistency between different types of signing: This includes several aspects, such as: consistency of the successive limits, consistency in the reflective sheeting of the signs (to ensure good service life and safety at night), consistency between road signs placed at the same location, consistency between road signs and road markings (in specific cases, it is possible to paint speed limits on the road), consistency between fixed and variable signs, etc. This is not always easy to achieve, as shown in the figure 6.2.

Figure 6.2. **Example of inconsistency between fixed and variable message signs**

Source: CERTU

For variable message signs, a significant problem is the impossibility of establishing a hierarchy between variable and fixed signs presented close together to inform the driver which of the two types of sign has priority, as until now the variable signs look like the fixed ones (in countries that signed the Vienna Convention). Over time, the fixed speed limit signs may have to be removed altogether from locations where variable speed limits are considered necessary.

- ***Spacing between speed limit signs*****:** This is particularly relevant for local speed limits. It is important to help the driver to remember what the speed limit is at all times. Countries generally use a 500 metres to 1500 metres spacing between consecutive signs.

- ***Implementation issues*****:** They have to be considered carefully: Location and type of supports, choice of sign type to ensure good visibility (clear, and with good contrast), and precise placement (in order to enhance the visibility of the panels).

Despite the various rules which exist relative to the local implementation of signing, it may also be valuable to adopt a consistent approach for a whole road section. For instance, if a succession of critical points requires a different speed limit, it might prove useful to adopt a common speed limit for the whole section. A general review should therefore be undertaken to find the most efficient and credible solution.

Furthermore, one should take great care when there are changes of speed limit, by displaying either an "end of limit" panel, or another speed limit (depending on the practices in each country).

Lastly, one must pay particular attention to transition zones between sections with large variations in their speed limits. In some countries for example, two consecutive speed limits are not allowed to differ by more than 20 km/h (in this case the distance between two successive panels could vary between 100 and 200 metres). Other countries merely use an advance sign informing drivers of the reduced speed ahead, which is a logical practice if there is no change of road environment where the sign is posted. This transition can be applied to all lanes or to one lane only. In the latter case, an additional panel is needed.

Dynamic and variable speed limits

In the case of dynamic speed limits (*e.g.* as applied on urban or rural motorways to regulate traffic), attention should be paid to the credibility of the system. For this reason, speed limits should not be displayed – or should be set at a very low level – when traffic is blocked.

Furthermore, the speed limit on a given variable message sign should not be changed too frequently.

As an example, in the case of speed regulation on motorways (Aron *et al.*, 2001), it is recommended that variable message signs be spaced in such a way that when a motorist goes through one gantry, he/she can already see the next one (approximately equivalent to 500 metres spacing). This is usually done within the framework of a so-called FTMS – Freeway Traffic Management System, where the speed limits depend on the weather conditions (rain, wind, fog…), the traffic volume, the congestion ahead, etc. (Nouvier, 2001 and PIARC).

One question is whether or not it is advisable to indicate, with variable signings, different speed limits for different lanes on the same cross section of road. While this option is possible in some countries (such as The Netherlands and Italy), it is forbidden in others (such as France) (SETRA, 1994), or even compulsory in others (Luxembourg). Unfortunately there is no validated study from which to draw clear conclusions. However, one can envisage that displaying different speed limits on the same cross section of road may lead to an increase in lane changes and therefore increase the risk.

Perception of signs and limitation of signing

On wide roads (*e.g.* 2x3 motorways), it is recommended to place speed limit panels on both the curb and median sides of the motorways, in order to increase the perception of the limit and to be sure that the panels may be seen by the driver (otherwise, a truck or a series of trucks, could prevent a driver from seeing a panel placed on one side only). The panels could also be placed on a gantry over the road.

Furthermore, as mentioned previously, signing needs to be consistent with the infrastructure and with usage. As an example, a speed limit sign should be posted when effectively entering a built-up area, which is not necessarily at the administrative border of the village.

It is also important that the driver knows at all times the actual speed limits. This is particularly important on road sections with many changes in speed limits. As well, in countries with a large number of automatic speed cameras, drivers want to know at any time the current local speed limits. Some countries use very small signs in addition to the regular signs, which replicate the illustration on the prescribed sign and are located on guard rails, at relatively close spacing. Figure 6.3 shows an example (the diameter is 150 mm here) from the Netherlands motorway network limited at 100 km/h. Sweden had adopted such signs at one stage, but decided to remove them in accordance with their strategy of reducing the number of signs.

Figure 6.3. **Sign used on motorways in the Netherlands to remind drivers of the speed limit**

Source: CERTU

Existing signing must remain visible all the time (*e.g*. foliage must be removed, when necessary). It is thus highly recommended that periodic audits be conducted, during the day and at night time, by professional drivers who do not know the road well.

It should be pointed out that, during the night, the driver has fewer visual clues to the design of the road than during the day. The importance of road signing, including road marking, is therefore higher during the night (SETRA-CERTU, 1990).

6.2. Road markings

Road markings also play a role in the driver's speed choice. It is important to bear in mind that road markings have four functions:

- Firstly and most obviously, to guide the drivers, for example to allow the drivers to easily drive in one of a number of lanes.

- Secondly, to inform the drivers of regulations such as no overtaking, no parking, etc. This function has an effect on the drivers' driving choices. For example "overtaking" lengths are usually calculated based on the type of road and the actual speeds of vehicles. However, if actual speeds are too high, there is a risk of entering a vicious circle: long "overtaking" lengths, which favour higher speeds, may encourage infrastructure managers to increase these lengths even further. It is therefore important to base marking design on the speed limit and not the actual speeds of vehicles.

- Thirdly (and this is more directly linked with speed management): some road markings such as "shark teeth", or transverse stripes with a very specific distance between them, etc., can have a direct effect on speed perception (see below). Of course, their use depends on the regulations in force in each country.

- Finally, road markings might give advance warning of road alignment ahead.

Many studies on the influence of road markings on speed have been undertaken.

Denton (1971) investigated the hypothesis that by modifying the spatial structure of the road environment, it should be possible to compensate for speed adaptation mechanisms, notably at the approach to transitional situations. To do this, he used transverse marking patterns consisting of a series of white lines whose spacing was gradually and exponentially reduced. Compared to a road with no markings, drivers who encountered the transverse markings made greater reductions in their speed.

This type of intervention was subsequently introduced under real conditions at approaches to driving situations where drivers are required to reduce speed, such as approaches to roundabouts, bends or motorway exit ramps (see, for example, Denton, 1973; Helliar-Symons, 1981; Malaterre, 1977, Shinar *et al.*, 1980; Taylor *et al.*, 1995). Assessments of such markings generally show that drivers reduce their speed, although it is uncertain how long the effect lasts (Martens *et al.*, 1997).

A more systematic investigation of various road markings and their combinations was carried out by Goodley *et al*. (1999) within a research programme on the effectiveness of "Perceptual countermeasures to speeding" (PCM). Perceptual countermeasures were defined as "manipulations of the road scene presented to the driver that can influence his or her subsequent behaviour". In a series of simulator studies, they examined the speed reduction associated with a representative sample of PCMs (using transverse, centreline or edge-line road markings) installed either at the approach of transition zones or along roads involving continuous driving. Finally, the authors demonstrated that perceptual lane width narrowing is effective in reducing drivers' speed along roads during uninterrupted driving.

Rumble stripes

Rumble stripes are a speed control measure at the boundary between road marking and road engineering. Rolling noise is amplified when driving over transverse rumble stripes. When spaced at progressively decreasing intervals, rumble stripes can give the driver the feeling of accelerating and thus encourage the driver to slow down. They must however be applied with caution: they should not be implemented near dwellings (because of the noise generated) and they should in principle not be used on 2-lane roads except if there are separate lanes (to avoid perverse effect).

6.3. Urban signing

Given the fact that current road signing started on rural roads and is better adapted to rural than urban roads, ideally one can imagine reinventing signing in urban areas to make it more coherent with the urban needs and the environment (Nouvier, 2000). However, in reality, we have to use what is available, and pay special attention to the following:

- The placement of the panels.
- The role of specific road markings (*e.g.* for parking spaces), which can sometimes be used in place of sign panels.
- The existence of “zone panels”, which display information applying to an entire area, and not only on a road stretch. This can be applied, for example, in the 30 km/h zones.

6.4. Signals: “moderating" green waves and other uses

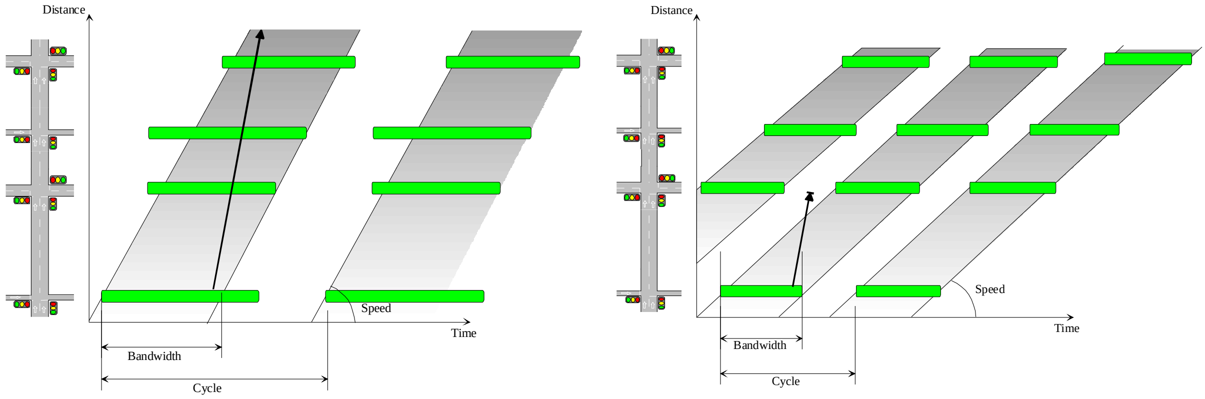
In urban environments, traffic lights can also be used for speed management purposes.

“Green waves” is the term used to describe the strategy of regulating traffic flow by means of traffic lights. This approach is designed to minimise journey time and stops on major roads by adjusting three parameters: cycle time, green times (“bandwidths”) and coordination speed. With a green wave, the operator can improve the fluidity of the network (but this does not increase the throughput).

A new way of envisaging green waves has been devised recently; the “moderating” green wave, using low speeds of coordination and narrow bandwidths. In this way it is possible to reduce and homogenise the speed of vehicles as, in this scenario, the drivers see in front of them only one or two lights at “green”.

Figure 6.4 compares a normal green wave with a moderating green wave. It shows on the left, the principle of a normal green wave. The horizontal axis represents time, with the succession of “green periods”, the vertical axis represents the distance between the intersections and their traffic lights. On the right, it shows the principle of a moderating green wave: the bandwidth is reduced, and the coordination speed is also decreased (typically from 50 to 40 km/h or even less). With a moderating green wave, drivers cannot go much faster than the programmed speed and they usually cannot “catch up” with the wave ahead. Moderating green waves are very useful for reducing speeds, notably in periods when speeds can be high (*e.g.* during the night).

Figure 6.4. **The principle of a moderating green wave**

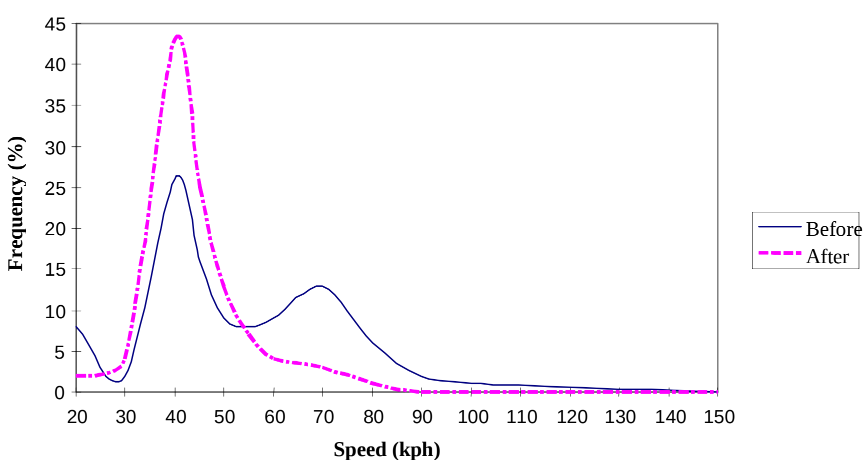


Source: Chauvin, J.M. (1999)

Experimental programmes with green waves carried out in French towns are also showing promising results (see figure 6.5). These experiments have been conducted for the most part under fluid traffic conditions (mainly at night) and on one-way systems. The reductions of speed obtained are in the order of 10 to 20% in average speeds, and 15 to 25% in the speed exceeded by 15% of vehicles (85th percentile speed) (Chauvin, 1999). However, some towns have also applied the same principle at peak times, without having observed any serious malfunctions.

Moderating green waves are easier to implement on one-way roads. There are difficulties in using green waves on two-way streets, especially for traffic going in the non-peak or cross-direction. In addition, as for other green waves, some drivers may be tempted to "catch" a moderating green wave by driving at a very high speed, but it is much more difficult. Despite these limitations, however, moderating green waves constitute an excellent solution to traffic flow and speed management problems in dense urban areas.

Figure 6.5. **Change in speed distribution before and after the implementation of a moderating green wave in Rennes (France)**



Source: CETE, Normandie-Centre (France)

In the context of pollution alerts and restrictions on circulation, it should be noted that moderating coordination strategies can contribute both to limiting the level of pollution and to calming traffic, which in turn has a positive impact on road safety.

6.5. Other signals-related tools to communicate with drivers

"Red waves"

In an alternative application of the green wave principle, reverse programming of traffic lights could be applied to ensure drivers face a red light at each intersection. Of course, this would discourage motorists from driving on these roads, by practising a sort of "anti-coordination" with long periods of "red" and a lot of stops for the drivers.

Such anti-coordination should not be considered a long term solution to local problems. Traffic lights are, in effect, safety and traffic management devices, and it is increasingly difficult to ensure that they are obeyed. It is important, therefore, to ensure that they retain their credibility.

"Spanish" traffic lights

Several countries including Spain and Portugal use traffic lights to "penalise" drivers who drive too fast. The system detects vehicles approaching too quickly at a given location (usually a town or village entrance), and the traffic lights turn to red to stop the vehicle. The traffic lights are generally placed at an intersection or near a pedestrian crossing. Informative signs may be put in place before the traffic lights.

Such systems are widespread in some countries, as they constitute a simple response to the problem of speeding at the entrance to urban zones. However, they also have a number of disadvantages. For example:

- If the traffic light is located at an intersection, or at the location of a pedestrian crossing, it is more likely that a vehicle approaching too fast will not be able to stop, thus risking crashing into another vehicle or running over a pedestrian. The location for the speed sensor must therefore be carefully selected.

- If the traffic light is isolated, its credibility might be questioned. In such a case, one might consider these traffic lights to be detrimental to road safety in general – even if they are intended to improve safety at a given location.

Based on current knowledge, such systems are controversial and should be used with great care. However, a variant (see below) seems to offer better prospects.

A possible alternative

There are other possible options to the traffic lights concept mentioned above. For instance, a traffic light at the entrance to a village can be set to red by default, and turn to green only if the approaching vehicles respect the local speed limit. If it is not the case, the drivers must stop for a certain period of time. This can be applied in places with low levels of traffic.

This alternative system is used in some countries and constitutes an improvement of the aforementioned system. It also requires, though, very careful implementation.

Consideration of the actual speed of vehicles approaching traffic lights

In some countries, when a car driving too fast is identified before a traffic light (increasing the risk that the driver will violate the red light and possibly cause an accident), it is possible to change the operation of the traffic light:

- By extending the "green" time, which is strongly not recommended, as this has a perverse effect of encouraging the driver to go faster;

- By extending the "clearance red" which delays the green for the other vehicles for their protection.

Similar systems that provide a green period for transit buses, trams, or emergency response vehicles, can improve safety and reduce emissions for those vehicles, but do not have a specific objective relating to the speed of general traffic.

6.6. Other means of communicating

Another option for communicating specific information to drivers is via the media. This is used in some countries (for instance, France) in the event of an expected pollution peak. In theory, such information on maximum speeds diffused by the media can have legal standing and override roadside signing. Even though it is difficult to enforce this in practice, there have been some good results, *e.g.* in Grenoble.

Furthermore, it is interesting to highlight a recent French initiative, where users can communicate directly with the French Minister of Transport through a Web site (address: www.ditesleauministre.com – "say it to the Minister") to alert the Ministerial services to signing failures and, in particular, locations where speed limits do not seem appropriate. The success of such a programme requires a good follow-up system to set-up and maintain a real dialogue with the public.

"On the spot" information can be given to the driver through a variable message. For example, if a driver arrives too fast at a dangerous bend, a variable message sign can display the speed limit at the spot, possibly alternating with a "bend" sign.

Usually, this type of message does not differentiate between different categories of vehicles. However, in some countries, such as Canada, special messages can be displayed for trucks, particularly before sharp bends, as long as the vehicles can be recognised by the systems in place.

Some countries measure the actual speed of the vehicles and display a message on variable message signs (either the actual speed itself, or a message like "too fast"). Such systems may, however, induce a perverse effect, *e.g.* if some road users try to "beat records" knowing that no punitive measures are associated with such information systems. However, this effect is limited if the message only indicates "too fast" and not the actual speed for those exceeding the speed limit. Figure 6.6 shows a sign displaying the current speed of each vehicle in real time.

Another new system that is becoming more widely used calculates the average speed of vehicles over several kilometres of motorway and, after automatically reading the vehicle plates, displays the number plate details of speeding vehicles on variable message signs (with the message: "too fast", if this is the case) (Schwab, 2005). Such systems can also be used for automated enforcement, as is done in the case in the Netherlands. There are other similar systems which are mobile and can be used for example to measure speeds at work sites. These systems display the plates of vehicles having been driven too fast in the work zone.

Figure 6.6. **Variable message sign displaying the speed limit and the current speed of the vehicles** (United States)

Source: CERTU

Finally, it is noteworthy that it is technically possible for the information provided by external signs to also be displayed on-board the vehicle. Such a system is being tested in a small area of Germany where speed limits, no overtaking and other messages are displayed on the dashboard.

6.7. Other aspects

Particular case of tunnels

In tunnels, compliance with speed limits and minimum headways (distance between vehicles) are basic safety elements. To ensure compliance, a binding system (for instance to limit the number of vehicles on a certain section of road) could be set up or, alternatively, an information-only system. See also chapter 10 on new technologies.

Long downhill grades

Special attention should be paid in order to avoid excessive speed by trucks on long downhill grades. Special informative signs can therefore be installed to recommend to downshift and to use engine brakes (see figure 6.7). In some difficult cases, variable message signs should also be used.

Figure 6.7. **Signs for trucks before a downhill grade (Czech Republic)**

Source: CDV

Role of the media

The media has an important role to play in making the signs known and well understood. By working in close co-operation with the media, the road authorities can reinforce the importance of signing in achieving road safety and environmental outcomes as well as improving the comprehension of the signs by the public. When important new signs are introduced, they should be adequately "promoted". As well, campaigns on the benefits of variable messages signs, for example, and the use of signals can have beneficial impacts.

6.8. Policy considerations

In many countries, signing and signalling systems are designed according to standards set out in the Vienna Convention. National guidelines concerning their general implementation and installation are intended to ensure that such systems are easy to understand and effective in operation in their different settings. Experience has shown that much progress can still be made relating to the installation and effectiveness of signing. To ensure their improvement, it is highly recommended that periodic audits be conducted, during the day and at night time, by professional drivers who do not know the road well.

Variable signing offers new perspectives and possibilities (notably, traffic regulation on motorways) in the field of speed limitation. Variable signs can deliver messages suited to the current road conditions, and are therefore more credible than fixed signs, but they are also much more expensive and need to be well organised and managed properly. However, a day could perhaps be envisaged where fixed speed signing will become "obsolete".

Road markings are important in influencing drivers' speed choices. They guide and inform the drivers and can have a direct impact (*e.g.* as in the case of transverse stripes).

Traffic lights can also be used to manage speed. However, the way in which traffic lights are used for this purpose should be carefully considered and monitored regularly as, in certain circumstances, such uses may be potentially dangerous.

More generally, the effectiveness of signing and signalling cannot be assessed at a location level only. Broader consideration needs to be given to area and system wide effects. Improved consistency and overall public credibility are important objectives in this wider context.

Lastly, it is important that the media recognise the importance of signing and lend their support. Information should be disseminated through the media when any new signs appear in the list of panels used in a country.

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CHAPTER 7.

INFLUENCE OF CURRENT VEHICLE TECHNOLOGIES ON SPEED

This chapter covers speed management systems that are either standard or optionally available in current motor vehicles. They can be considered conventional, as opposed to intelligent transportation systems (ITS), as they do not involve an exchange of information with other vehicles, infrastructure or communication networks.

The chapter discusses the impact of the various characteristics of the vehicle which influence speed, such as the engine and the speedometer. It reviews current technologies to assist the driver in choosing the appropriate speed, including speed limiters, conventional cruise control, adaptive cruise control and speed monitoring systems. Finally it provides considerations for policy makers.

Intelligent speed management systems are addressed in chapter 10.

Over the past 50 years, there has been tremendous progress in the vehicle industry. Considerable advances have been made in vehicles technologies that have significantly improved the passive safety of vehicles. In particular, these technologies have allowed for much better protection of vehicle occupants in the event of a collision. At the same time, the average maximum speed and accelerative performance of passenger cars have greatly increased. There has also been a notable trend towards higher performance among sport utility vehicles (SUVs) and light trucks. Technologies have been developed which directly or indirectly impact the speed and speed behaviour of road users

7.1. The influence of vehicle characteristics on speed and safety

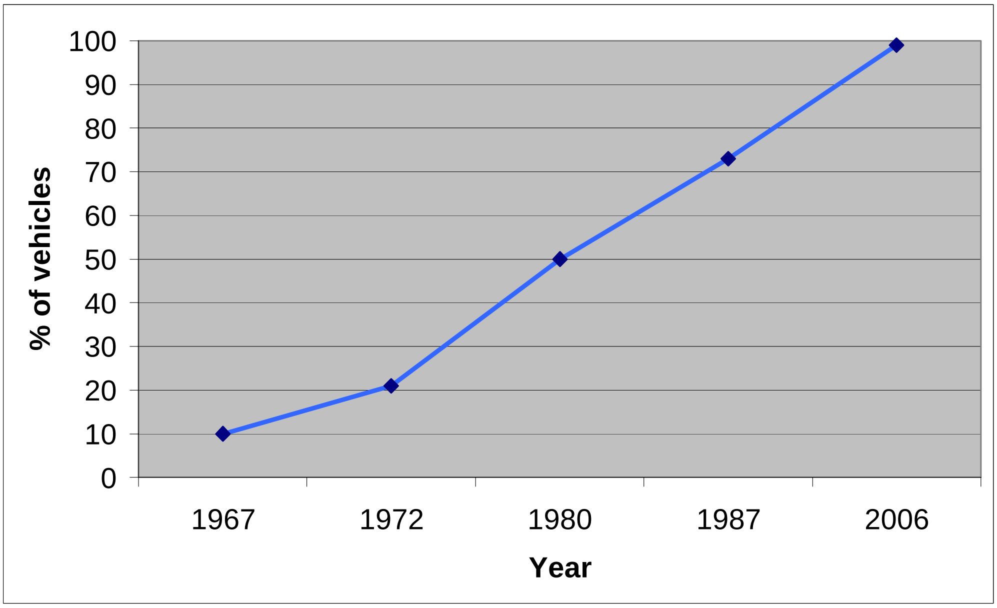
Maximum speed and engine power

In the absence of a speed limiting system, a motor vehicle's maximum speed is dictated mainly by its engine power, and also by rolling and air resistance. In establishing the maximum power for a particular passenger vehicle, for example, the manufacturer must consider operational requirements including acceleration, maintaining speed up hills and against head winds, carrying a full load of passengers and cargo and towing a trailer. In such circumstances (and combinations of them) the driver may need to call up maximum available power by fully depressing the accelerator. In contrast, relatively little power is required to maintain legal speeds on a level road with no wind, typically about 20 kW (25 horsepower) at 100 km/h. Thus, for passenger vehicles, the surplus power normally available can accelerate the vehicle to speeds far in excess of the legal limits in force in countries where there are speed limits. The same conclusion can be drawn equally for sport utility vehicles, light trucks (especially in North America) and motorcycles. However, limiting the power of the vehicles will not solve the speeding problem, especially in urban areas, as even with reduced power vehicles would still be able to exceed urban speed limits.

Transport authorities have frequently been called upon by lobby groups to restrict maximum speed or engine power or power-to-weight-ratio in order to reduce fatalities and injuries in collisions, energy use, and traffic noise. However, maximum speeds of private vehicles have historically been unregulated essentially due to the lack of popular demand or political incentive. Performance is a popular selling feature and speed is often glamorised in automobile advertisements (Shin *et al.* 2005). Maximum speeds of passenger cars, light trucks, sport utility vehicles and motorcycles have increased greatly over the past 30 years. In Germany, where speed is unrestricted on some parts of the motorway system, vehicle manufacturers have had an informal agreement for several years not to produce vehicles with maximum speeds greater than 250 km/h. However, a recent report (just-auto.com, July 12, 2005) indicates that the manufacturers are abandoning the agreement in order to satisfy customer demands for faster cars.

Most of the passenger vehicles sold in 2005 can reach speeds far above the maximum regulatory speed limits set by the countries in which they will be driven. This is illustrated in Figure 7.1.

Figure 7.1. **Percentage of vehicles sold in France capable of travelling more than 150 km/h**



Source: Nouvier and LAB

Today, in most countries, there are speed restrictions requiring limitations directly on the engine for two categories of vehicles: trucks and mopeds. The public has been more willing to accept rudimentary speed restrictions on mopeds and motorcycles in view of the relatively high risk of injury to motorcycles riders, particularly those of limited experience, in collisions.

In many countries, it is common practice to limit the engine power of mopeds and smaller motorcycles and to allow riders to operate larger motorcycles only after they have experience with mopeds or smaller motorcycles, which are easier to operate than larger motorcycles and generally have lower maximum speeds. For example, learner riders in Great Britain and the state of Victoria, Australia are restricted from riding motorcycles with engines of greater than 125 cc and 260 cc respectively. Evaluations of these regulations showed mixed results:

- In Victoria, the number of injuries per rider in the year after passing the driving test fell by around 33%, compared to an 8% increase for fully-licensed riders (Troup *et al.,* 1984).
- The British experience was not successful: the total number of injury accidents involving novices did not go down, but simply shifted from larger motorcycles to the type of machines learners were allowed to ride. During the same period injury accidents involving experienced riders decreased by 10%.

A review of 13 evaluations of the relationship between motorcycle engine capacity and accident rates (Elvik and Vaa, 2004) found considerable variation, and concluded that there is scarcely any gain in safety either through banning motorcycles with large engines or regulating them more stringently. The best-controlled study (Ingebrigtsen, 1989) showed only a 5% increase in accident rate for motorcycles with engines over 825 cc compared to those under 425 cc.

Studies in Norway and Germany (Fosser *et al,* 1992, Löffelholz *et al,* 1997, cited by Elvik and Vaa (2004)) have shown that mopeds with illegally modified engines producing more power than allowed by the relevant regulations had injury accident rates from 1.48 to 2.8 times that of unmodified mopeds. The simple modification of air intake restrictors on moped engines is a particular example that increases the risk to young riders. It is therefore important that there are strong enforcement efforts against engine modifications.

In relation to passenger cars, analysis of collisions in France has shown that male drivers under age 30 driving vehicles with higher power to weight ratios are involved in more severe collisions than young male drivers of lower performance vehicles. However, crash involvement of female drivers and male drivers over age 30 is much less affected by vehicle performance (Fontaine, 1994).

In comparison to passenger cars, heavy commercial vehicles are often more powerful but their acceleration and speed capabilities are much less, due principally to their much greater weight and larger frontal areas (higher aerodynamic drag). On highways, a large proportion of heavy trucks limited (with speed limiters) to a speed below the general speeds desired by drivers of other vehicles may have a slowing effect on traffic. In recent years, a trend to more powerful engines in trucks has allowed higher acceleration, although still below that of cars, and has reduced the negative effect of hilly terrain on average speeds.

Influence of vehicle design

Simulation studies (Rudin-Brown, 2004; Rudin-Brown and McCurdie, 2004; Lee, 1995) as well as experimental evidence suggest that drivers of SUVs, pickup trucks and vans are less able to judge speed accurately because they sit higher above the road than drivers of passenger cars. An explanation lies in visual optic flow: the angular velocity of points in the far periphery of the driver's eye fixation decreases as driver eye height increases relative to the ground. Worryingly, while three-quarters of the subjects noticed the difference in eye height produced by the simulated view, only one-third were aware they were driving faster at the greater eye height, and some even thought they were actually driving slower than at the lower eye height. The perception that they are travelling slower than they actually are may make drivers of SUVs and light trucks drive too fast for certain conditions, thus aggravating the greater rollover propensity of those vehicle types compared to passenger cars (Rudin-Brown, 2004).

In sum, these findings suggest there is certainly some potential to manage speed and safety by controlling vehicle performance characteristics, notably engine power or weight-to-power ratio, in carefully targeted circumstances.

7.2. Types of speed management systems

The following sections present various vehicle-based systems in approximate chronological order of development, which equates to decreasing reliance on driver control and increasing complexity.

7.2.1. Speedometer

The inability of humans to judge speed accurately resulted in the introduction of the speedometer on automobiles in the first decade of the 20th century. The speedometer is essential to the driver for maintaining a desired speed, particularly for observing speed limits.

Analogue and digital speedometers

Speedometers are generally subject to national or regional type approval regulations (*e.g.* European Commission, 1975), many of which incorporate an international regulation (UN/ECE, 2003). In the United States and Canada, state and provincial highway traffic laws require speedometers on all vehicles driven on public roads. Regulations typically specify that the speedometer must indicate not less than actual speed, thus providing a margin of error in favour of safety. The maximum permissible instrument error ranges from 6% (Society of Automotive Engineers, 1983) to 10% (UN/ECE, 2003). The range of speed indicated typically surpasses vehicle maximum speed (see figure 7.2). On typical analogue (moving needle) speedometers with very high maximum speed indications (as on high performance cars and motorcycles), the closely spaced markings make significant changes in speed relatively less noticeable by the driver than would be the case if the markings were spaced further apart.

Usually, constant speeds can be read faster and more accurately on digital displays, but the moving pointers of analogue displays are superior for presenting changing speeds, typical of motor vehicle traffic. Compared to digital displays, analogue displays also have a slight but consistent advantage in terms of maintaining a set speed, ability to detect events on the road while checking the speedometer, number of glances required and cumulative time spent checking the speed (Kiefer and Angell, 1993). Analogue displays could be improved by clearly indicating the common speed limits (in particular urban speed limits). Theoretically, they could be designed in a way that the most common driving speeds (30-90 km/h) are the most visible. In addition, speedometers should not show speeds that are much above the actual maximum speed of the vehicle. Most speedometers today give the same space to indicate speeds between 0 and 120 km/h and speeds between 120 and more than 220 km/h. One can wonder whether this gives the right message to drivers (see figure 7.2). Some manufacturers use a varied scale, *i.e.* a larger scale for lower speeds as shown in Figure 7.3, which gives more visibility to the more practiced speeds.

Figure 7.2. Typical analogue speedometer.

Source: www.321auto.com

Figure 7.3. Speedometer with a varied scale

Source: Rights reserved.

Figure 7.4. Digital speedometer

Source: www.dnaspeedometers.com

Figure 7.5. Head-up displays

Source: www.uk.news.dupont.com

Digital speedometers offer a number of benefits: more legible, more "neutral" (one does not see high speed). But there are also disadvantages, such as inertia (to avoid the displayed speed changing all the time).

Head-up displays

Head-up displays (HUDs) have appeared on a small number of passenger vehicles in recent years. Automotive HUDs project speed and other information through the windshield where it is superimposed on the driver's view of the roadway (see figure 7.5). Automotive HUDs display selected functions and can be switched off. Studies conducted to date are inadequate to support an accurate assessment of either operational benefits or the safety-related risks associated with automotive HUDs. Two areas have not been sufficiently addressed: the optical distance at which HUD imagery should be focused and the effect of HUD images on visual attention to outside objects (Tufano, 1997). However, HUDs technology is evolving fast and the most recent versions have been significantly improved. Further research is needed to understand whether HUDs may play a role in the choice of speed by the driver.

Location of the speedometer

On some vehicles, speedometers are located centrally rather than directly ahead of the driver. It is interesting to consider whether a central speedometer might lead passengers to have more influence over driver's choice of speed. While research concerning the effect of passengers on speed has been done, no studies of passenger interactions with the speedometer display were found.

7.2.2. Engine speed limiters

Engine speed limiters operate indirectly in limiting road speed. The maximum road speed attainable by a vehicle equipped with an engine speed limiter corresponds to the maximum or "governed" rate of rotation of the engine output shaft. Governors were developed in order to prevent engine failure from extreme mechanical stresses that could occur, for example, in downhill running or through intentional speeding. All modern diesel engines are equipped with speed limiters, as are most petrol engines. As electronic speed limiters have replaced mechanical ones, maximum speed capability can be changed by replacing or reprogramming a microchip rather than by mechanically altering the engine. This development has allowed maximum road speed to be set at the factory or the dealer, a common practice in the cases of commercial vehicles in North America and passenger vehicles sold to rental agencies, but not to individual purchasers.

7.2.3 Road speed limiters for trucks and coaches

Speeding of commercial vehicles in member countries has increased in recent years. This is partly due to the fact that trucks are equipped with more powerful engines to handle heavier loads and to maintain trip times and that the demands of industry for "just in time" delivery place additional pressure on transporters to operate trucks at higher speeds to make up for potential delays. European and Australian transport authorities have responded to the resultant speeding by legislating the use of road speed limiters. Road speed limiters (RSL) act independently of the engine governor, although the two functions are increasingly integrated into "power train" computers.

An EC Directive (92/24/ECE) requires RSLs on trucks over 12 tons and buses manufactured after 1 January 1988; the specified limits are 90 and 100 km/h, respectively. The Directive has since been extended to light commercial vehicles over 3.5 tons, and passenger vehicles with more than nine seats (ECE 2004/11). Research supporting the regulation showed positive effects on emissions and fuel consumption through prevention of over-speeding.

The EC Directive requires RSLs to be generally resistant to tampering and not to be adjustable while the vehicle is in motion. However, the illegal modification of RSLs to allow higher speeds continues to be a problem.

RSLs set to 100 km/h have been required on heavy trucks in Australia since 1991. The regulations allow a tolerance of 5 km/h for technical variations. The effective RSL limit is therefore 105 km/h. RSLs can have some side impacts. In some cases, the results of traffic flow measurements on major truck routes showed that road capacity (vehicles per hour) could deteriorate over time as the proportion of speed-limited trucks rises. RSLs increase the time required for RSL-equipped vehicles to overtake other traffic. Overtaking of speed-limited trucks by other vehicles tends to increase on 2-lane roads, which could result in more truck-related collisions (Tan, 1995).

Transport operators generally favour RSLs for their positive effects on fuel consumption. However, RSLs do nothing to reduce speeding on roads with speed limits below the RSL setting, nor on downgrades steep enough to cause free-rolling. In some cases, truck drivers may be tempted to always reach the maximum speed set by the limiters. In addition, the overtaking between two heavy vehicles may take a long time.

However, overall, RSLs have contributed significantly to reducing accidents involving trucks. There are many countries where speed limiters are not used and consideration should be given for mandatory speed limiters for trucks and coaches.

7.2.4 Conventional Cruise Control

Conventional cruise control (CCC) was introduced on production cars more than 50 years ago. CCC responds to speed changes caused by wind, rolling resistance or gradient by continuously adjusting the fuel supply to maintain the set speed. The driver activates the system manually when the vehicle has attained the desired speed. The system maintains the set speed without further driver action until it is deactivated either manually or through applying the brakes. CCC reduces driver workload as it requires less concentration to monitor the speed and keep it in the desired range.

Cruise control is not mandatory in any country. However, its performance characteristics are specified in technical standards (*e.g.* Society of Automotive Engineers, 1988).

CCC has followed different developments in Europe and North America, due to different behaviours and road network shape (for instance, the motorway network represents a larger share of total traffic in North America compared to Europe).

7.2.5 Adaptive Cruise Control

Adaptive cruise control (ACC) is “an enhancement of conventional cruise control systems that allows the ACC-equipped vehicle to follow a forward vehicle at a pre-selected time gap or headway (distance) (see general principles of ACC in figure 7.6) by controlling the engine, power train, and/or service brakes” (Society of Automotive Engineers, 2003). The driver selects the cruising speed as with conventional cruise control, but can also adjust the time gap or headway (typically from 1 to 3 seconds).

ACC uses radar or laser sensors to detect and track vehicles on the road ahead. When a slower vehicle is detected in the travel lane, ACC reduces the engine fuel supply and if necessary, applies the brakes until its speed matches that of the lead vehicle or a set maximum level is reached. As with conventional cruise control, the driver can deactivate ACC by applying the brakes or switching it off.

ACC has been the subject of intense scientific study. Mathematical modelling suggests that, deployed in sufficient numbers, ACC can reduce speed variations in traffic. More uniform speeds have been shown to reduce collision risk. Collision data analyses also suggest that ACC could be a possible countermeasure in 7.5% of collisions (5% of fatal, 4.4% of non-fatal injury, 8% of property damage collisions) (Chira-Chavala and Yoo, 1994). However, research also suggests that drivers may become overly reliant on ACC when they become accustomed to its operation, increasing the risk of collision (Rudin-Brown and Parker, 2004).

Figure 7.6. **Principle of ACC**

Source: www.motorsportcenter.com

It is expected that the penetration of ACC into the market will increase rapidly over the next ten years, replacing conventional cruise control. ACC combined with collision warning, mitigation and avoidance systems is now available on some top range vehicles. "Stop and go" ACC systems that allow speed control in slow traffic (0 to 40 km/h) were introduced on some 2006 model vehicles.

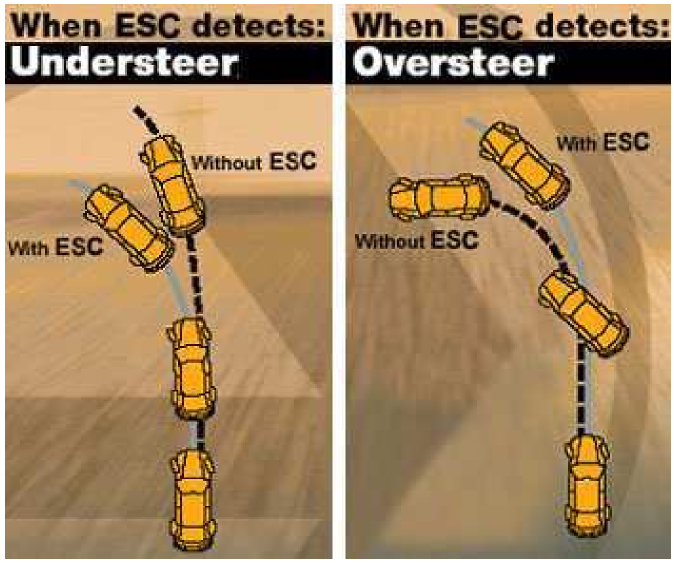
ACC is a speed management system, which appears as an essential precursor for a more comprehensive safety system that integrates inter-vehicle distance control, collision warning, mitigation and avoidance functions.

7.2.6 Electronic Stability Control Systems

Electronic Stability Control (ESC), also called Electronic Stability Programmes (ESP), uses sensors to measure the speed of each wheel, the steering wheel angle, vehicle yaw rate (the rate at which it is changing direction) and lateral acceleration. When the system detects that actual vehicle motion is different from the driver's desired path (as measured by the steering wheel sensor), it automatically applies braking and/or reduces engine power at each individual wheel to bring the vehicle back under the driver's control. This helps drivers to maintain control of their vehicle by avoiding excessive under steer and transient over steer. ESC also has the effect of slowing the vehicle down during loss-of-control situations (especially in curves or on surfaces with different friction coefficients).

Field research in Europe, North America and Japan has consistently shown that ESC is effective in reducing single vehicle loss-of-control accidents involving serious injury or fatality by more than 30%. For instance, analysis of Swedish collision data indicates that 16 to 20% of fatalities could be saved if all vehicles had ESC (Lie *et al,* 2004).

Figure 7.7. **Principle of Electronic Stability Control (ESC)**



Source: Continental Teves

Due to the high potential of ESC to reduce accidents, the US National Highway Traffic Safety Administration has placed a high priority on ESC research. Furthermore, the European Commission now recommends that all new cars be equipped with ESC/ESP.

Speed reduction is a side effect of the ESC system's efforts to maintain control in locations where the ESC of a particular vehicle happens to activate. ESC is therefore not expected to have a systematic effect on traffic flow.

7.2.7 Speed Monitoring Systems

Event Data Recorders

Vehicles can be equipped with devices that record a number of parameters to improve safety. There are three types of data recorders:

- *Recorders*, installed by car manufacturers and only accessible to them, which record in a continuous manner a number of parameters mainly focused on the operation of the engine. These parameters are used by the research departments of car manufacturers mainly to improve the construction of their engine and by the garages for breakdown diagnosis.
- *Event data recorders (EDR*) – sometimes referred to as "black boxes" – record certain parameters a few seconds prior to, during, and after an accident, including vehicle speed, acceleration, air bag deployment and some other occupant-based variables. EDR systems record data continuously, but retain it for only a brief period of time (about 30 seconds) before, during and after a collision. The stored information is useful for collision reconstruction and in aggregate form can ultimately be used in analyses of causal factors in populations of collisions to improve motor vehicle safety. Data privacy and right of access are the major issues surrounding broader use of EDRs. If such issues can be resolved, EDRs may be expected to have a positive effect on driver behaviour, including speed choice, as noted below.

- *Advanced event data recorders* which can monitor driver behaviour in a continuous manner and which can be used for fleet monitoring and also for controlling the speed behaviour of drivers.

Within the scope of the Work Programme for the Promotion of Road Safety in the European Union 1997-2001, the European Commission stated “accident data recorders record important data on the collision and thus considerably facilitate accident analysis. The use of EDRs (US NHTSA, 2001) results in less collisions because the drivers drive more carefully”. NHTSA published a final rule in August 2006 for standardisation of EDR data that will ensure that EDRs record, in a readily usable manner, the data necessary for automatic accident notification, effective accident investigations, and analysis of safety equipment performance. Because of the relatively high new vehicle fleet penetration of EDRs in the United States (estimated at 64% for 2005 model year and expected to rise to 85% by 2010), NHTSA felt it was not necessary to mandate the installation of EDRs in all new vehicles but rather to standardise the EDR data recorded. In addition, analysis of EDR data can contribute to safer vehicle designs and a better understanding of the circumstances and causation of accidents and injuries. The rule requires manufacturers to ensure the commercial availability of the tools necessary to enable accident investigators to retrieve data from the EDR. To ensure public awareness of EDRs, the regulation also requires vehicle manufacturers to include a statement in the owner’s manual indicating that the vehicle is equipped with an EDR and describing the functions and capabilities of EDRs. Light vehicles manufactured on or after September 1, 2010 that are equipped with an EDR must comply with this rule.

The European Commission is funding the VERONICA (Vehicle Event Recording based ON Intelligent Crash Assessment) project whose objectives are to obtain real accident data to assist in improvement of road infrastructure, vehicle design, driver behaviour (pre-, crash and post phases) and medical needs. In France, a study of driver behaviour when EDR is installed is expected to be completed in 2008.

Tachographs

Mechanical tachographs (instruments which record on a paper chart the speed, total distance travelled between stops and resting periods of a truck) are widely used for professional driving and are compulsory in most countries. They are used by police forces and transport operators to control the numbers of continuous driving hours and resting time as well as maximum and average speed on an itinerary. In practice, they are not easy to tamper, however they can quite easily be disconnected, which makes reliable control difficult.

Electronic tachographs are increasingly installed voluntarily on commercial vehicles, as original equipment or retro-fitted, to allow real time monitoring of speed, to log drivers’ hours of service and other parameters, and to track cargo. Electronic tachographs have rapidly supplanted mechanical tachographs due to their ability to record data in addition to speed and time, that can be downloaded either at the end of a trip or after a certain length of time for computerised analysis. The effectiveness of electronic tachographs depends on active and continuous involvement of fleet management (US DOT, 1991). Nevertheless, the use of electronic tachographs on commercial vehicles has contributed significantly to improvement in road safety. Studies of European fleets found that driver and employee awareness of an on-board electronic tachograph reduced the number of accidents by 20 to 30 per cent, lowered the severity of such accidents, and decreased associated costs. These studies have generally been based on small samples and concentrated on commercial applications of electronic tachographs (Lehmann *et al* 1998).

Electronic tachographs are now compulsory in the European Union on new heavy good vehicles (> 3.5 tons) and on new passenger vehicles carrying more than 9 persons.

Further development is taking place regarding electronic tachographs and it is expected that within a few years, it will be possible to control a truck in operation without stopping it.

Aftermarket speed monitoring devices

Aftermarket monitoring devices that permit collection and analysis of trip data by private vehicle owners are also available. Some insurance companies have started to offer premium discounts and rewards to drivers who agree to install a monitoring device that collects information statistically linked to insured risk, including distance driven, speed, and the distribution of trips by time of day and day of week. Drivers can download the information to their home computer to review their driving patterns at any time. They can then choose whether or not to submit their data to the insurance company over the Internet to receive discounts. This has been implemented with success in Ireland. In some other countries (*e.g.* France), such a practice has not been authorised for privacy reasons.

Advanced speed monitoring systems

There are many developments in monitoring systems that can allow dynamic tracking of vehicles through GPS. Advanced data recorders can record speeds continuously (through GPS) and compare them to speed limit databases thereby monitoring speed at any time. These systems can be used for fleet management and could also lead to a "self enforcement" system (see as an example, the experience of Iceland with the application of dynamic event data recorders in Box 7.1). However, this raises the issue of the "*Big Brother*" spectre for civil liberties groups, who may be unwilling to accept these new developments.

Box 7.1. **Application of Dynamic Event Data Recorders in Iceland**

The SAGA system, developed by an Icelandic company, is a complete information system for monitoring and reporting:

- Location and utilisation of vehicles.
- Speed compared with speed limits.
- Driving behaviour according to predefined criteria.

SAGA is used in the vehicle fleets of 70 companies. After data is processed and analysed, results are downloaded onto an SQL-database. Reports on the data analysis are sent out to the owner by e-mail. Iceland Post is one of the companies using the system. Since its introduction, significant improvements in driver behaviour have been noted, including less speeding, and a reduction in accidents. The system also leads to savings in operational costs of the fleet, especially in fuel consumption. Comparison of January-June 2005 statistics with those of the same period in 2004 shows the following results:

- 56% reduction in accident cost.
- 43% reduction in the total number of accidents.
- 51% reduction in the number of accidents, where employees are responsible.

Some versions of the system can send automatically messages and fines, when infringements are made (self enforcement). However, acceptability issues of such system are a major concern.

Source: Jonsson R, (2005)

Box 7.2. **Application of EDRs in Saudi Arabia**

According to IBM, the United Arab Emirates will implement an in-vehicle traffic management system which will provide authorities with the capability to monitor dangerous driving and respond to emergencies. When a car goes above the speed limit, the device gives the driver a warning and sends authorities data on the route the car is taking. According to reports, the system will be installed in "tens of thousands of vehicles" starting during 2006.

Source: IBM

7.2.8 Fuel consumption indicators

Trip computers available on many vehicles can display the fuel consumption rate. Recent large increases in fuel prices makes this a feature of high interest to drivers. There could be soon on-board indicators integrating the price of petrol with trip times and distances, so that the driver has direct and on-time information on the cost of travel, including the effects of speed on fuel consumption.

In France, a joint venture between the industry and the road authorities is developing a driving assistance system– called GERICO – to encourage eco-driving. The system informs the drivers of the fuel consumption and the corresponding fuel price and gives dynamic advice on actions to reduce it (such as changing the gear, reducing the speed).

7.3. Other aspects

7.3.1. Comfort properties

Early studies revealed the role played by auditory information in drivers' speed perception. Speeds are systematically underestimated when the driver is deprived of auditory information (Evans, 1970; MacLane and Wierville, 1975). Matthews and Cousins (1980) studied the role of noise level in relation to vehicle size, and found that compared to drivers of large vehicles, drivers of "small" vehicles were better able to estimate their vehicle's speed. Furthermore, depriving these drivers of auditory information had a greater negative impact on their speed estimation than drivers of large vehicles. In summary, human factors research indicates that reducing the noise level in vehicles can, in the absence of limiting factors including traffic and drivers' reference to the speedometer, cause drivers to increase their speeds.

Interior noise levels in both passenger and commercial vehicles have declined due to improvements in design and manufacturing of vehicle structures, together with the increasing application of air conditioning, double-glazed side windows, and other noise reduction techniques. The research suggests that reduced noise levels of modern vehicles and improved ride and handling may contribute to reduced driver awareness of actual vehicle speed. On the other hand, these applications also have a positive impact on road safety, as they reduce fatigue and other stressing factors of driving.

7.3.2. Gearboxes

Gearbox staging and the proportion of cars with automatic gearboxes can also have an impact on driving style. Additionally, current staging of gearboxes is not specifically optimised for urban areas and it can sometimes be difficult to respect the speed limit. The choice of gear, especially in 30 km/h zones, can lead to poor engine optimisation (too fast), and thus to an increase in the fuel consumption and the pollution emitted by the vehicle.

7.4. Influence of vehicle safety regulations and safety rating schemes

In official vehicle rating systems such as the US New Car Assessment Program (NCAP) and EuroNCAP, tests are done at speeds which are representative of a large number of accidents (around 60 km/h[1]) while in real life, impacts often occur at higher speeds.

Furthermore, criteria in vehicle safety regulations are based generally on speeds that are representative of the vast majority of traffic conditions as well as collisions. Adherence to reasonable speeds should thus improve the performance of all safety devices.

7.5. Policy considerations

Maximum speed capabilities of most vehicles are well in excess of regulated speed limits and requirements of normal driving situation on open roads. Some lobby groups have therefore requested limits on the power of the engines or the power to weight ratio, as well as activation of the speed limitation capability in electronic engine control systems. While limitations on vehicle engine power or power-to-weight ratios may be beneficial in specific circumstances (for example for heavy vehicles driving on rural roads), this would not solve all the speed related problems, especially in urban areas.

Governments may need to consider whether maximum vehicle speeds should be restricted to levels more consistent with highway and motorway speed limits.

This is obviously a contentious issue, not well accepted in all countries, touching on perceived mobility "rights" and public reservations about ceding control over driving choice to authorities. This will require careful consideration and extensive consultation with all stakeholders.

Regarding speedometers, consideration should be given to encouraging designs which give more visibility to the legal speed ranges on the speedometer display and provide less prominence to speeds over 120 km/h.

The simple modification of air intake restrictors on moped engines is a particular example that increases the risk to young riders. The ready availability of aftermarket engine computer microchips for some passenger cars enables drivers to obtain greater acceleration and maximum speeds that once required expensive mechanical modifications. It is recommended that governments strengthen their enforcement efforts against illegal engine modifications or tampering of speed limiters, in conjunction with periodic emission control tests of vehicle in use.

A number of driving assistance technologies are being developed. Adaptive Cruise Control (ACC) can assist drivers in complying with speed limits as well as improve safety and their introduction in new vehicles should be encouraged. Similarly, electronic stability control (ESC or ESP) has so far proven very effective in reducing accident risk and the wider introduction of these technologies on passenger vehicles should also be encouraged.

On-board monitoring systems (such as event data recorders) provide incentives for responsible driving. Manufacturers are generally installing EDRs in a significant proportion of their new vehicles and this trend should be further encouraged. Rules are needed requiring EDRs to collect standardised information (as is the case in the United States). Pilot programmes with speed monitoring systems providing reduced insurance rates for drivers who comply with speed limits are showing promise

1. Frontal impact at 60 km/h; side impact at 50 km/h and collision against a pole at 29 km/h.

(even though they are not accepted in every country) and need to be evaluated publicly. Governments need to encourage the insurance industry to take more such initiatives to curb speeding behaviour and reduce accident risk, and to evaluate their effectiveness.

Road speed limiters are mandatory in Europe and Australia for trucks and coaches and should be encouraged elsewhere. Usually, vehicle technologies to moderate speed also have a positive impact on the vehicle fuel consumption and emissions. This should be made known more widely to support the introduction of these technologies. Effective speed control across the entire range of existing speed limits requires technologies that recognise the actual speed limit. Such "intelligent speed adaptation (ISA) systems are discussed in Chapter 10.

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CHAPTER 8.

EDUCATION, TRAINING, INFORMATION AND INCENTIVES

Education, training and information are essential elements of a comprehensive speed management policy. They are clearly focussed on achieving safe driver behaviour and improved road safety outcomes. They make a contribution to the improvements that a comprehensive speed management approach can deliver and complement the specific measures taken including those related to safer infrastructure, clearer and more consistent signing, vehicle safety and enforcement**.**

This Chapter discusses the possibilities and limitations of education, training and information as potential means to influence drivers' traffic behaviour in general and their speed behaviour in particular. It reviews the approaches to education of children, young road users, and drivers as well as driver training, and information and education aimed towards licensed drivers.

8.1. Introduction

Education, training and information are essential elements of a comprehensive speed management policy. They are a prerequisite for success with other elements of a policy package, such as infrastructure measures, enforcement, speed limits, traffic signs and vehicle engineering. Regulations and supportive safety measures will be more effective and better accepted if people are familiar with the regulations and know how they apply to them, as well as understanding the reasons for those regulations and the measures taken to support them. The aim, through education, training and information, is to achieve a sustainable change in traffic behaviour by influencing people's opinions and attitudes, thereby establishing an intrinsic motivation to behave in a safe and correct way.

This Chapter discusses the potential, and limitations, of education, training and information as a means to influence (future) drivers' traffic behaviour in general, and their speed behaviour in particular. The first section deals with primary and secondary school children, for whom education is the main instrument. The second section focuses on learner drivers and the role of driver training. The third section deals with licensed drivers. This is by far the largest group, but unfortunately also the one that is most difficult to reach; with general information campaigns being the most common instrument for communicating with them.

Many countries offer driver improvement courses, but these are normally restricted to drivers who have committed serious or repeated violations. While most of these courses focus on drink-driving violations, there are some examples of driver improvement courses following speeding offences. More recently, new technologies have become available which allow continuous monitoring of all types of driving behaviour, including speed. This technical innovation has resulted in a number of experiments with incentives for good behaviour, which are also outlined in the Chapter.

8.2. Education of children

Most road safety education and training takes place informally, and is provided principally by the family and outside the school. Parents and other adults in a child's circle have a responsibility to set a good example. They need to be aware that their behaviour, opinions and remarks play an important role in a child's way of looking at the world in the future.

In the framework of speed management, there is only a limited role for education of *primary school* children; they are not really in a position to influence the speed of motorised vehicles themselves. This does not mean that speed and speed management are not important for children; they certainly are. Children at a young age are directly affected by the risks that speeding vehicles represent for them. Policy deliberations are focussed on the importance of young children not becoming victims themselves. Clearly, children are most at risk from motorised vehicles being driven at speeds which are (too) high, particularly in locations where pedestrians are concentrated and where children play. Children may also be disadvantaged as well as impacted, as such driving not only raises road safety risks for them but also detracts from their independent mobility and their ability to play outdoors.

Educating children regarding road traffic therefore requires attention to the risks and a focus on behavioural strategies to avoid potential conflicts with cars. Even though some approaches work better than others, establishing a reliable and lasting effect on a child's traffic behaviour has proved very difficult to achieve (Björklid, 1998). While children may learn to behave in a perfectly safe manner under simple and controlled conditions, they may not be able to apply that learning in more complex situations – and certainly are not able to do so when they are distracted. The explanation for this is that children are not able to divide their attention; they devote themselves to one thing at a time, and thus, as a group, they will always remain unpredictable road users (OECD, 2004).

These insights provide some understanding of why speed management is important, particularly in respect of locations likely to be frequented by children *e.g.* in residential areas and near schools and playgrounds. It is clear and certainly important for the traffic environment to be designed - and for driving speeds to be adapted - to the capabilities of children, rather than expecting children to adapt to the speed of traffic on the roads.

However, even in this context, the education of children can still have added value. An example which illustrates the point is the "Safe Route to School" programme in Australia. The multi-action approach that was taken combined education, engineering and, where appropriate, enforcement. It was found that casualty rates were substantially lower for primary school-aged children attending schools that ran the programme, than for other, similar, schools which did not (Delaney *et al.*, 2003).

At *secondary school*, children are reaching the age at which they are allowed to participate in traffic, initially on a bicycle and later with a motorised vehicle – perhaps a moped first, then possibly a motor scooter or motorcycle and finally a car. The school can fulfil an important role in the preparation of this transition to high speed and risky transport modes by including some road safety education in school classes or activities in one form or another.

Road safety education at school may be embedded in a broader approach to traffic and transport. In Sweden, for example, projects have been developed in which traffic and transportation issues are addressed from a social perspective, with emphasis on several areas: environment, health and survival, economic issues and society's need for transport. The aim is to get young people interested in traffic and to encourage them to see that the use of motor vehicles is more complex than a matter simply of an individual's transport needs. An evaluation study of one of these projects showed small but still significant effects on attitudes and behaviour (Gregersen and Linderoth, 1997).

Studies on the effects of speed could also be integrated into subjects on the school curriculum, such as physics (*e.g.* braking distance, impact speed, g-forces), chemistry (exhaust emissions), and human science (*e.g.* reaction time, resistance of the human body to impacts). However there need to be sufficient links with reality, *i.e.* the effects of speed on accidents, accident severity, quality of air in residential areas, for the realities of road safety to not be forgotten. Practical training therefore also remains a critical element of effective education, not only for young people before they become car drivers, but also before they become moped and motorcycle riders.

Parents can contribute to their children's road safety education by not speeding and not glamorising driving at high speeds in the presence of a child. Parents and society generally can help by protecting children from literature and television that glamorises speeding. It should also be noted that, while children do not have a direct role in traffic, they may still be able to (strongly) influence the speed behaviour of their parents. For example, when the speedometer is visible to vehicle occupants (*e.g.* children in the back seat), children who are made aware at school of the concerns about speeding would be in a position to alert their parents if they start driving over the speed limit (see chapter 7).

8.3. Learner drivers and driver training

8.3.1. Young and inexperienced drivers

Learning to drive is a complex and long-term process. It involves acquiring knowledge, developing driving skills, and correctly assessing risks and one's own ability. This is not easy, as can be concluded from the fact that novice drivers are largely over-represented in accident statistics (OECD/ECMT, 2006). The vast majority of learner drivers are young; therefore a good driver training programme should be based on a thorough understanding of the characteristics of young people.

According to Gregersen (1998), the three main problems for young drivers, and an explanation for their high accident risk, are:

- The tendency to overestimate their abilities and to underestimate the risks.
- Lack of motivation to take sufficiently wide safety margins.
- Lack of experience.

Recent studies into brain maturation have demonstrated that even at the age of 18 the human brain is still developing, in particular those brain areas that are dealing with impulse control and integration of information ("thinking before acting"). This finding may form a biological base for the tendency of young drivers to take high risks, fail to notice hazards, etc. (Gogtay *et al.*, 2004; Giedd, 2004).

Furthermore, young people are often very susceptible to peer pressure. Many studies have shown that there is a correlation between the presence of passengers and driver behaviour (Engström *et al.*, 2003). Young drivers have been found to drive faster and with shorter following distances when they have young passengers in the car. This was the case for both male and female young drivers, but the largest effect was found for young male drivers with young male passengers (OECD/ECMT, 2006).

8.3.2. Speed as an issue in driver training

Driving too fast for the conditions may be one of the consequences of the tendency to overestimate one's skills, underestimate the risk and succumb to peer pressure. Therefore, the issue of speed and speeding should be prominent in young driver education and training. The foundations, however, can be laid at an earlier stage, namely when youngsters start to ride mopeds or light motor cycles, generally at the age of 15 or 16. This is the first time that a youngster, as a rider, is in touch with motorised traffic and one of its most important characteristics: speed. This issue could be dealt with as part of the school curriculum, in theoretical training or, even better, during practical training for a motorised two wheeler (*e.g.* moped) driving licence.

The message that the instructor has to instil, however, is not an easy one to convey. During the practical training, for example, driving instructors will tell the learner drivers to keep to the posted limit. But if they do so, numerous other cars will overtake them, with no evidence to show that going above the speed limit leads to negative consequences (an accident or a speed ticket). Another example is that instructors explain, almost in contradiction with the foregoing, that it is important to adapt to the speed of the traffic stream. Often, however, these speeds are higher than the given speed limit. So it is important that driving instructors themselves are educated, not only on the issue of speed and its effects, but also on how to pass the message to their pupils.

8.3.3. Accompanied driving and a graduated driving licence

The lack of experience of young drivers is a problem because, in order to gain experience, they must drive in traffic and expose themselves (and others) to the risks associated with inexperience. This was once considered an insoluble problem, but many countries have now developed driver education systems in which young drivers gain more experience through practice on the roads before they acquire a licence for solo driving; for example by driving under the supervision of a parent (accompanied driving). It has been shown that drivers who were trained under such a system have fewer accidents during the initial stages of driving with a licence (Engström *et al.*, 2003). An important factor is of course the supervisor's attitude to speeding; there is a risk that, if this person does not recognise the importance of the right choice of speed, the informal driver training could encourage novice drivers to drive faster.

In a graduated licensing system (the type in force in countries such as Australia, Canada, the United States and New Zealand), the accompanied driving stage is followed by a period during which the novice drivers are allowed to drive independently, but with a number of restrictions to protect them from high risk situations. These generally involve limits on blood alcohol levels (and therefore on alcohol consumption) and may also include restrictions on night-time driving and driving with passengers of the same age. They can also relate to speed limits (differentiated speeds for novice drivers). The experiences have been positive and resulted in substantial decreases in accidents involving young drivers (SWOV, 2004).

8.3.4. Driving skills courses

It is possible to take driving courses which improve specific driving skills. These courses usually focus on particular driving conditions, such as slippery roads.

Driving courses that focus on vehicle handling skills, such as anti-skid training, can have adverse effects if they lead to overconfidence in the driver. For example, Glad (1988) reported an increase in slippery road accidents after skid training became a mandatory part of the Norwegian driver training. Finnish results (Keskinen *et al.*, 1992) pointed in the same direction. Following the introduction of skid training, a larger proportion of young male and female drivers' accidents occurred under slippery road conditions. In Sweden, a voluntary training programme for licensed motorcyclists also seemed to increase the accident risk (Ulleberg, 2003). It should be noted, however, that these experiences come from countries where driving in slippery conditions is frequent because snow is a common occurrence.

One explanation for these outcomes is that this type of training generally focuses on exercising manoeuvring skills, which can result in overconfidence in one's ability to handle the vehicle. Instead of using their enhanced skills only in critical situations the students may also draw on them under normal driving conditions and, for example, choose a higher speed. Another possible explanation is that drivers might feel more competent after completing the course, without actually having improved their skills. An additional reason may be that they have improved driving skills that do not help them avoid accidents, since accident involvement may reflect behaviour and is not necessarily the result of poor driving skills.

This does not mean that drivers and riders should avoid practising handling skills. However, the courses would need to pay more attention to recognition of hazardous situations, avoidance of these situations and, last but not least, to the limitations in driving skills.

PC-based training with driving simulators is a new development which offers an alternative. Research shows that this kind of training can be effective in practising vehicle skills without inducing overconfidence in one's driving ability (Regan *et al.*, 2000). Currently, much research is going on to explore and develop the possibilities of simulator training for learner drivers, for example in the framework of the e-learning projects in the European Network of Excellence HUMANIST (www.noehumanist.org), and this could be particularly useful for truck drivers. However, road safety researchers generally agree that simulators are not a substitute for the necessary levels of on-the-road driving experience.

8.3.5. Optimising the potential effects of driver training and education

There is often disagreement regarding not only the overall usefulness of driver training and education but, for those in support, what topics should be covered and which methods should be used. Several common recommendations and conclusions for better driver education have been made (*e.g.* Engström *et al.*, 2003), most of them related to speed in an indirect way:

- Reflection on personal experiences in traffic and self-evaluation must be included in training programmes and demand active participation.

- Programmes should address issues of responsibility, perception, decision-making and young people's tendency to take risks.

- Consideration of the interaction between emotions, attitudes, goals and motives, should be a standard element of young driver education and training programmes.

- Gaining driving experience while under supervision is an important protective factor against the accident involvement of novice drivers. To maximise this effect, the learner driver would need to encounter many and different traffic conditions, and supervisors would benefit from educational material to support their role as monitor.

- Driver training methods that not only identify risks, but also allow young drivers to actually experience risks as well as the associated emotions and personal shortcomings, are more effective.

- Professional training programmes, combined with structured supervised practice and protection for high-risk situations in the first period of independent driving, have enormous potential to reduce accident involvement, both during the training stages and first years of unsupervised driving.

Evidently the safety aspects of speed must be an essential part of driver training, and it should be clear to the driver that speed is one of the major factors in road accidents. Training and education concerns drivers of all types of vehicles (including motorcycles and heavy good vehicles). Driving simulators for truck drivers should also be encouraged as they allow the drivers to acquaint themselves with a wide variety of situations. It is also crucial that driving instructors be properly trained and sensitive to the issues of speed. They must be capable of explaining to their pupils the effects of speed on the occurrence, frequency and severity of accidents, and of teaching appropriate speed behaviours. In January 2006, the Ministry of Transport in France organised a colloquium for driving instructors which included several sessions on speed as well as stopping distance, visual perception, impact force, etc. (Ministry of Transport, 2006). So far, the feedback on this initiative has been very positive.

8.4. The licensed driver

8.4.1. Information campaigns

Licensed drivers are by far the largest group of interest for speed management purposes, but they are also very difficult to reach by education and training measures. The majority of countries use information campaigns for this purpose. These focus either on speed generally, or raise driver awareness on specific measures, such as the launch of an enforcement campaign.

Despite their popularity, the effects of information campaigns as a means of changing attitudes and behaviour are hard to prove, especially if they are applied as a stand-alone measure. This does not mean that information campaigns are a waste of money and effort. In fact, they are crucial to creating awareness of a particular safety problem, and an absolute prerequisite for introducing, explaining and supporting new regulations (*e.g.* the introduction of low speed zones) and specific measures (*e.g.* targeted police enforcement). There is empirical evidence that road safety campaigns, which normally consist of information as well as other measures – such as enforcement, rewards, legislation or education – help to improve road safety. For example, a meta-analysis of evaluation studies of targeted road safety campaigns showed an 8.5% accident reduction during campaign periods (Delhomme *et al.*, 1999). It is not possible to judge the effect of the information *per se,* however, as these results must be attributed to the combined components of the campaign.

In the case of speed, an information campaign message is hard to get across, as it is difficult to convince individuals to change their speed behaviour. On a personal level, people experience mainly the positive consequences of speed (they enjoy it, just get a green traffic light, reach their destination more quickly, or at least subjectively believe the time saving is significant). On the other hand, they rarely experience themselves the negative consequences (more traffic casualties, more pollution), which are only visible at an aggregate level. Therefore the effects of speed information campaigns *per se* on behaviour, without supportive measures, are expected to be very small, or non-existent. The fact that information campaigns have little effect, unless accompanied at the same time by other actions and measures, was also the conclusion of an Icelandic study (Jonsson, 2004): an intensive speed-reduction campaign had no significant effect on speed distributions on the main highways.

One specific problem is that drivers generally think that they are better and safer drivers compared to others (Evans, 1991). Safety messages may therefore be considered to be appropriate for others, but not for oneself. This mechanism was found by, for example, Walton & McKeown (2001), who assessed whether public safety messages concerning speed had effectively reached their target audience. They found that drivers who think they drive faster than average accept the message to reduce speeds as aimed at them. Most drivers, however, believe that they drive slower than average, and are more likely to ignore this type of message.

Delhomme *et al.* (1999) reported that road safety campaigns are more effective when they are carried out at a local level. Lourens *et al.* (1991) evaluated three local information campaigns aimed at reducing driving speed in residential areas, improving drivers' observational behaviour and increasing the subjective risk of drivers of running into a child. Looking at both reported and actual speed, they found indications that the information campaigns had had a positive effect, although this had been difficult to demonstrate statistically.

The messages of the road safety campaigns should be focussed on the consequences of speeding. Information campaigns should be well-designed and based on a theoretical framework. One example is the Scottish campaign "Foolspeed", which is based on the psychological Theory of Planned Behaviour (see Box 8.1). An evaluation study showed that the campaign is effective in triggering the desired communication outcomes and is associated with significant changes in attitudes and beliefs about speeding (Read *et al.*, 2005). No evaluation in terms of actual speed behaviour has been carried out on the study to date. While the requirement of a good design and a theoretical basis seems to be an eminently logical one, many of the current campaigns are lacking a theoretical basis.

Box 8.1. **FOOLSPEED: A Scottish Road Safety Campaign on speeding**

Foolspeed is a major publicity initiative aimed at reducing the use of excessive and inappropriate speed on Scotland's roads. The aim is to change the way we think about speeding in urban areas, challenge the beliefs we have in our driving ability and highlight the benefits of choosing to drive at speeds appropriate to conditions. It demonstrates the unnecessary strain drivers expose themselves to by ignoring the speed limits on Scottish roads and highlights the everyday benefits of choosing not to speed such as reduced stress levels and starting the day with a clear head.

Launched in November 1998, Foolspeed is modelled on the psychological theory of behaviour change, the Theory of Planned Behaviour (TPB). The TPB is a structured model with an interacting combination of 3 concepts: salient beliefs, subjective norms and perceived behavioural control. Using the TPB as a basis for the initiative ensures a focused and structured approach to the publicity activity. The publicity campaign is following a number of key stages. The initial stage involved building an identity for the campaign which forms the anchor through the following stages of the initiative.

A series of short (10 seconds) TV adverts were used to launch the logo. These adverts challenged the different salient beliefs drivers hold regarding their speeding behaviour, such as "I am a good driver therefore I can speed" and "I can always stop in time". A full length (40 second) television advert called 'Mirror' aimed to further challenge driver beliefs. The second full length advert titled 'Friends & Family' looked at the effect of driving at inappropriate speeds on passengers in the car. The third full length advert "Simon Says" addresses the perceived behavioural control element of the psychological model. It shows how drivers allow themselves to be "pushed" along and pressured by other drivers on the road. The advert challenges drivers to take control and not allow others to control their speed. Foolspeed launched its fourth consecutive ad on Monday 8th November 2004 and focuses on how people's attitudes and behaviour towards speeding impact on their well-being and that of other drivers.

Source: Road Safety Scotland *(http://www.roadsafetyscotland.org.uk)*

There has been much debate over many years on the issue of fear–inducing messages, and threat appeal versus the softer approaches (Figure 8.1). While research has not yet come to a definitive conclusion, the majority of studies show a positive relation between the arousal of fear and the convincing power of a message (Hastings & Kennie, 1999). Fear-appeal works best when it is accompanied by strongly stated solutions. It is especially persuasive to those who have been hitherto unconcerned about a particular issue and if the source is credible (Rensburg, 1996). Research has still to be done to identify optimum levels of fear arousal, since too high a level may have a negative effect. (Delaney *et al.*, 2003).

Figure 8.1. **Campaigns in the United Kingdom**

Source: UK Department for Transport

Advertising can also be in conflict with road safety aims. Advertisement campaigns produced for car manufacturers often promote high performance and high speed as a positive value; a way to enjoy driving more. According to *Automotive News* (2003), automakers spend huge amounts of money (USD 9 billion annually in the United States) on advertising; promoting, indirectly, unsafe driving practices. In comparison, the U.S. NHTSA requested USD 56.3 million in 2005 for all their highway safety programmes, committed for changing driver behaviour. According to a study, 45% of ads in the United States promote unsafe driving (or roughly USD 4 billion, based on the figure above); of this, 56% show speed violations. This translates to over USD 2 billion spent annually to promote speeding, whereas less than 1 percent is spent by the government agency on encouraging safe driving. (Shin *et al.,* 2005).

The ECMT issued a resolution on this issue, as far back as 1989, calling upon manufacturers and vehicle importers, as well as advertising agencies and journalists, to avoid advertising that ignores road safety requirements (ECMT, 1989). Some countries (*e.g.* United Kingdom, France and New Zealand) did develop a code, whereby car manufacturers agreed not to base their advertising campaigns on the speed properties of the vehicle.

In the context of rapidly rising fuel prices, there is interest in designing campaigns which carry several messages, such as reducing speed for safety, environmental *and* economic reasons.

8.4.2. Driver improvement courses

Generally, driver improvement or rehabilitation courses do not focus on the driving population at large; they focus on drivers who have committed serious traffic violations or reached a particular level of demerit points. These courses can be compulsory or voluntary, *e.g.* in combination with a reduction in the fine. Most driver improvement courses are related to drink-driving offences, while some focus on safe driving in general. Only a few countries apply driver improvement courses specifically related to speed offences, for example: Austria, Belgium and Great Britain.

The aim of driver improvement courses normally is to make drivers aware of the effects of a violation, the reasons why people commit such a violation, and alternative behaviours. The British Speed Awareness Course, for example, defined that, by the end of a course, drivers should be able to demonstrate the correct use of speed for a variety of hazards, and to identify:

- What causes drivers to speed?
- The disadvantages of speeding.
- The consequences of misusing speed.
- Different speed limit areas.

For methodological reasons, it is very difficult to assess the effectiveness of driver improvement courses. Evaluation studies that are based on the participants' self-reports largely find positive effects on (self-reported) attitudes and behaviour. Evaluation studies that looked at accidents generally report that the effects on accident risk are small (Ker *et al.*, 2005; Elvik & Vaa, 2004) or non-existent (Masten & Peck, 2003).

8.4.3. Incentives

Many psychological theories on learning and motivation propose incentives as a powerful means to modify behaviour: not (only) to punish wrong or undesired behaviour, but (also) to reward what is done well. In the area of road safety, the use of incentives or rewards to convince people to behave correctly and safely is not new either. While there are some who are sceptical about the benefits of using incentives, or feel that it is principally unjust to give rewards for something that is 'normal', the effects can be very positive (Hagenzieker, 1999).

In the past, incentive programmes were sometimes part of a targeted road safety campaign, for example for wearing seatbelts. A typical incentive was a small token. However one drawback of these incentive programmes was that they could only be applied to behaviour that was easily observed (*e.g.*

seatbelt use), and in situations where drivers (or other road users) could be stopped in order to be given the token. It was also rather labour intensive.

Current technologies, however, allow for automatic and continuous monitoring and registering of several types of driving behaviour, including driving speed. These in-vehicle monitoring systems, or black boxes, are increasingly used for the implementation of incentives programmes, although most are still being undertaken on an experimental basis. Speed is generally one of the target behaviours. Results of the pilots are encouraging, although there are some indications that the effects tend to fade after the incentives have stopped. Box 8.2 gives some examples of recent studies in the field on incentive programmes in relation to speed behaviour. The field trials so far have been small-scale, and further research would be needed to assess the possibilities for larger-scale applications and to identify the best procedures and types of incentives. It should also be noted that some of the initiatives can go against the principles of civil liberty in relation to the use of technology.

Box 8.2. **Some examples of incentive programmes with the use of intelligent technologies**

In a number of countries field trials have taken place, or will take place, to study the possibilities for introducing incentive programmes in combination with in-vehicle monitoring systems. Speed and speeding behaviour is one of the main areas of interest in this scheme. Incentives vary from bonus points to be exchanged for gifts, to a direct monetary bonus or a reduction in the insurance premium.

In Sweden, for example, a pilot has been carried out with 114 drivers. Each of them was given a certain amount of money to start with. For every minute of speeding they lost some money, the more they exceeded the limit the more money was deducted. At the end of the test period each participant received the amount that was left over. It appeared that during the trial, there were less speed violations, especially major violations, than before (Hultkranz & Lindberg, 2003).

In the Netherlands, a pilot was carried out with 62 drivers driving rented cars. Points could be gained and exchanged for gifts. The programme focused on speeding and close following. During the trial, a clear improvement could be observed, with less speeding and larger following distances and, as a consequence, less fuel consumption. Once the trial had finished, however, a substantial part of the effects disappeared, although some of the participants persisted in their improved behaviour (Belonitor, 2005).

In Denmark, a study is planned with an incentive programme for young drivers. In this instance the incentive is a reduction in insurance premiums when they do not speed (Schmidt Nielsen & Lahrman, 2005).

8.5. Policy considerations

Education, training and information are essential elements of a comprehensive speed management policy. They are also a prerequisite for other measures to be effective, such as legislation, infrastructure, signing, enforcement and vehicle engineering. If applied correctly, they allow road users to understand why speed management is important, and how specific measures can contribute to the achievement of appropriate speeds. Consequently, education and training can contribute to the acceptance of such measures by young people and in the general community. In future, they may perhaps also help with the voluntary use of new technology applications such as intelligent speed adaptation (ISA). However, education, training and information alone may not be enough to change drivers' attitudes and behaviour. While some approaches seem more promising than others, long lasting effects are hard to achieve.

The education and training of learner drivers is of course important, and the risks and disadvantages of speeding must become an explicit issue in driver training. However difficult the message is to deliver, it must be made clear that speed is a major road safety problem in most countries and one of the major factors – and often the key factor – in road accidents, which affects not only their own safety but also the safety of other road users. It is equally important that the driving instructors themselves are educated on the issue of speed and its effects. In countries that have theoretical or practical training for first motorised two wheelers (*e.g.* moped) riders, the issue of speed should already be broached during this stage, as it is one of the most important factors in both the number and severity of road accidents.

A graduated licensing system with professional training, a substantial number of hours of structured supervised practice and some evidence-based restrictions on the use of the car when starting to drive unsupervised (*e.g.* with regard to night time driving, the presence of passengers or the maximum speed) has most potential to reduce accident involvement of young, novice drivers.

Driving courses that focus on vehicle handling skills, such as anti-skid training, can be counter-productive if they lead to overconfidence in the driver. Those that focus on recognition of hazardous situations, avoidance of these situations and on the limitations of driving skills, are more effective.

Drivers who are already licensed form the largest group of interest in terms of speed management and speed reduction, but they are also very difficult to reach and most countries rely on information campaigns, *e.g.* roadside billboards or television broadcasts for this purpose. As previously indicated, information campaigns are indispensable when used to support other measures. If, on the other hand, they are applied as a stand-alone procedure the effect, if any, will be very small.

Driving simulators for truck drivers should be encouraged, as they allow the drivers to experience a wide variety of situations which would be too dangerous to test in reality.

New technologies increase the opportunities for continuous monitoring of the traffic behaviour of individual drivers, including speed choice and the incidence of speeding. A number of experiments have been performed to assess the effects of incentives on correct traffic behaviour. The results are promising and deserve further research in order to assess the possibilities for larger-scale applications.

The depiction of speed in advertising of cars, motorcycles and even SUVs, both in print and television media, is widespread. Such advertising encourages dangerous driving, particularly by young drivers, and driving at higher speeds generally. Governments need to take a firm stand and ensure manufacturers understand the need to replace the emphasis on speed with positive messages about the importance of speed reduction for road safety and the benefits of vehicle features and technologies that can improve safety while reducing journey times and the stress of driving. Rapid progress could be made through voluntary agreements on new advertising standards.

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CHAPTER 9.

ENFORCEMENT

In an ideal world, there would hardly be a need for any enforcement. However, as is obvious from the extent to which vehicles are travelling at excessive speed in all member countries, such a world does not exist. Enforcement is therefore an important and necessary measure for speed management purposes. Speed enforcement has significantly evolved over the past 10 years with a general increase in the focus of enforcement efforts and the increasingly widespread introduction of automatic speed control, which gives a new dimension to the enforcement effort.

This chapter describes the general approaches taken to enforcement of speed limits. It sets out general principles for effective speed enforcement and then focuses on the different strategies for speed enforcement, the different instruments that are currently available, and their effectiveness.

9.1. Introduction

In an ideal world, with logical and credible speed limits, self-explaining roads, consistent speed limit signing, as well as good information to road users about the consequences of inappropriate speeds and the rationale for speed limits, there would hardly be a need for enforcement. In such a world, the vast majority of drivers would voluntarily keep to the speed limits. Enforcement would only be needed for those few drivers who knowingly and deliberately exceeded the limits. However, such an ideal world does not (yet) exist. This is clearly shown by the large amount of speeding that is found in all countries and on all types of roads (see Chapter 3).

If undertaken appropriately, speed enforcement can be a very powerful measure that contributes directly to reducing the incidence of speeding and, hence, the number of fatalities and serious casualties. While enforcement should never be an objective in its own right, it continues to be necessary as an essential road safety activity which has a major impact on safety outcomes.

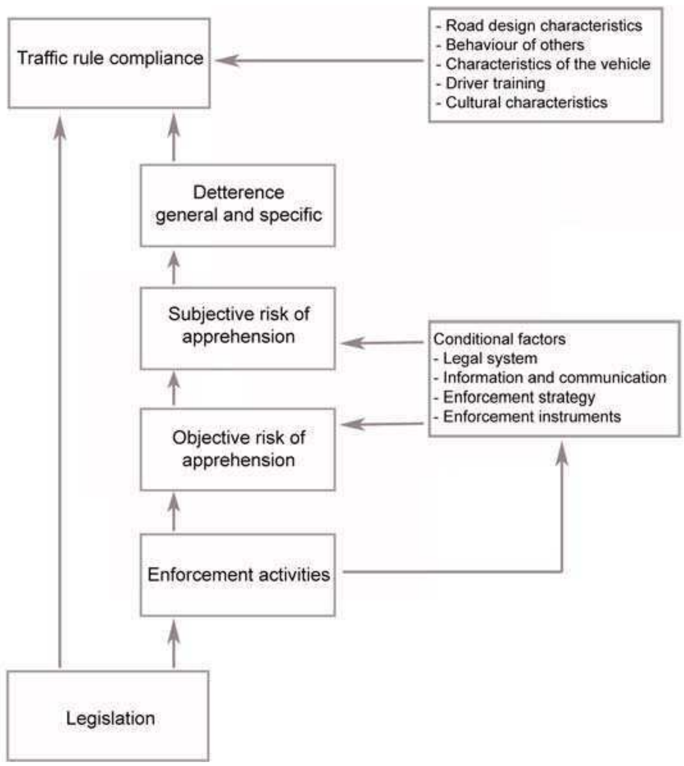
The chapter briefly describes the general principles and general approaches taken to enforcement and then focuses on the different strategies for speed enforcement, the various instruments that are currently available and their effectiveness. At present, it is not feasible –nor desirable — to constantly monitor all drivers and in future financial and manpower resources for traffic law enforcement will continue to be limited. The challenge therefore is to use the available resources as efficiently and effectively as possible.

9.2. Enforcement: how does it work?

The basis of traffic law enforcement is legislation, and the ultimate aim is to achieve compliance with this legislation. Whether drivers comply with traffic rules depends on the advantages and disadvantages of doing so and their relative value. Figure 9.1 shows a simplified model of the mechanisms for traffic law enforcement. The direct line from legislation to compliance in Figure 9.1 reflects those people for whom legislation is sufficient to make them comply. Police enforcement must be seen as a way to influence those for whom that is not the case.

Enforcement is based on the principle that people try to avoid a penalty, which is a disadvantage of not complying with the rules. The actual amount of enforcement activities determines the objective risk of apprehension. This objective risk of apprehension in turn affects the subjective risk of apprehension, *i.e.* the risk people believe there is. The subjective risk of apprehension can be increased by specific enforcement strategies and, very importantly, by publicity campaigns and attention to enforcement activities in the media. If the probability of apprehension is considered to be high and apprehension is followed by a fine or other sanction, most people will refrain from traffic law infringements. In this way, the subjective risk of apprehension provides the desired deterrence effect. In this respect, a distinction must be made between specific deterrence effect for those who are actually caught and the general deterrence effect for those who have not (yet) been caught.

Figure 9.1. **Model of the mechanism of traffic law enforcement**



Source: Goldenbeld, 2005/ Mäkinen *et al.*, 2003

The main conclusion to be drawn from this model is that the perceived chance of being apprehended when violating a rule must be sufficiently large to have the desired effect. If the chance is considered to be small, it may be associated with "bad luck" and not affect future behaviour. For example, a New Zealand study on the effects of speed enforcement (Povey *et al.*, 2003) measured the subjective risk of being caught. The conclusion was that the increased level of enforcement and, perhaps even more importantly, the increased perception of being caught, had contributed to both lower speeds and lower accident rates.

9.3. The selection of roads for speed enforcement

For the time being, and with the exception of some pilot studies with, for example, black boxes (see the experience of Iceland in Box 7.1), permanent monitoring of every driver, anywhere and at any moment, is not possible. Choices therefore have to be made about where to target enforcement efforts.

On roads with a bad safety record

Preferably, enforcement should be focussed on roads with a bad safety record, where speeding may be a common cause of accidents. Such targeting not only offers the best opportunity to actually realise safety benefits, but also makes it easier to explain the reason for enforcement to the general public. Enforcement should be – and be seen as – a safety measure and not a "fund raising" activity. Any sign or message that may give the impression that the latter is the case will attract considerable public criticism and should be avoided.

On roads with an appropriate speed limit

Enforcing speeds on roads where the speed limit is not consistent with road function and road design characteristics must also be avoided. When the speed limit is much lower than drivers would expect given the way the road looks, many drivers will exceed the speed limit. Speed enforcement will not be an effective solution in these circumstances, since it will undermine the credibility and acceptance of enforcement as a safety measure. The solution would be to ensure that the speed limit and the road characteristics are better matched. In this respect, regular consultation between police and road authorities will help to identify these types of "problem roads".

On roads with a subjectively high risk

The police may also be asked to enforce speeds on roads in residential areas and 30 km/h zones, because people feel unsafe due to actual or perceived speeding by motorised vehicles. Often the number of registered accidents is very small in these areas. Consequently, the effects in terms of accident reductions are likely to be very small or even non-existent. The primary reason to spend the generally limited resources for enforcement in these situations would be to improve the quality of life. A potential positive side effect may be a better acceptance of speed enforcement in general.

On all road categories

Whereas speed enforcement should focus on roads with a bad safety record, enforcement should not be limited to one road category. It is important that drivers become aware that speed control exists everywhere. For example, on motorways, which have the lowest accident risk, speed enforcement not only helps to reduce the incidence of speeding; since traffic volumes are large, enforcement on motorways also makes visible to many people that speed control exists. An "anywhere, anytime" enforcement programme is expected to increase the effectiveness of the enforcement undertaken.

9.4. General principles for effective speed enforcement

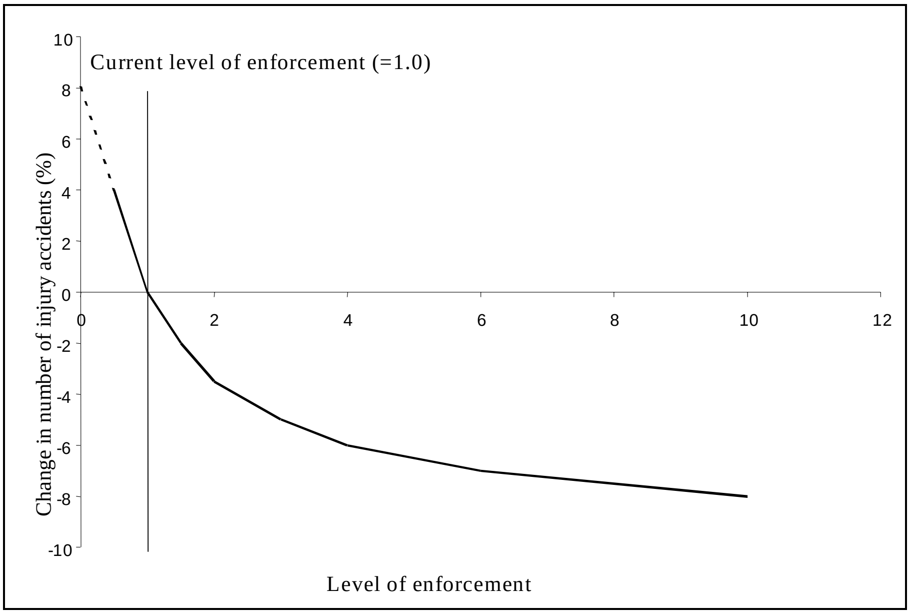
The effects of speed enforcement are known to be limited both in space and in time (*e.g.* Vaa, 1997; Christie *et al.*, 2003). Speed reductions are largest in the immediate vicinity of the surveillance unit. As soon as the surveillance site has been passed, speed will increase again. Similarly, when a period of intensified enforcement is finished, the effects will gradually disappear. In other words, the effects of police enforcement only last for as long as drivers perceive a high risk of being detected. There are a number of enforcement tactics and strategies that may help to maximise the effects of speed enforcement over space and time. These have to do with the frequency and intensity of enforcement, fixed *vs*. changing locations, visible *vs*. invisible enforcement, and the role of publicity.

Frequent, at irregular intervals and at different intensities

Speed enforcement activities are best repeated frequently, at irregular intervals and with different intensities. Higher intensities generally result in larger effects. However, as shown in Figure 9.2 the largest increase in effectiveness is found when doubling or tripling the enforcement intensity. By further intensification, the effects still increase but the added value becomes smaller, *i.e*. the law of diminishing returns.

Figure 9.2. **The relationship between the intensity of enforcement**

(1= current level; 2 = twice as high, *etc.*)
Doubling and the effects in terms of percentage change in injury accidents.



Source: Elvik, 2001

Variation in time and location

The randomness of enforcement is a major determinant of driver's subjective assessment of risk of apprehension. The exact location and time of speed enforcement should be unknown to drivers. The resulting unpredictability of enforcement actions will increase the sustainability of effects in terms of time and space. Therefore, in a particular area, the enforcement activities are best rotated randomly.

Both visible and invisible speed enforcement

On an average trip, the chance of seeing a police car or a police control unit is quite small. For example, in EU countries, the probability of drivers seeing a police car is less than once per 100 km travelled, and less than once per hour of journey (Mäkinen *et al.*, 2003).

High visibility police enforcement activities increase the subjective chance of apprehension. On the other hand, visible enforcement, contrary to invisible enforcement, will encourage drivers to adjust their speed only at that particular spot without any lasting effects.

Invisible enforcement has a major bearing on halo effects. Covert enforcement using mobile cameras, without signage to drivers, has proven to have a strong deterrent effect. An evaluation of the New Zealand speed camera programme found that the use of covert speed cameras to supplement overt cameras in signed areas generalised the effect of the programme beyond the speed camera sites. The use of visible symbols, such as signs warning of potential camera presence and marked enforcement vehicles, may help to remind drivers of the unseen threat of covert operations, thus increasing general deterrence (Delaney *et al.*, 2003).

A combination of both visible and invisible speed enforcement is highly preferred. In the latter case, the visibility of the enforcement can be enhanced by either a visible location where detected speeders are stopped by the police or, in the case of automatic speed enforcement, by an electronic sign saying “your speed has been checked”.

Supported by publicity and information

The effects of enforcement are substantially increased when supported by publicity and information. Accompanying publicity and information work in two ways. First, they increase drivers' awareness of speed enforcement and they also increase the subjective chance of apprehension. Examples of publicity and information serving this particular goal are the coverage of enforcement actions by the local media and billboards alongside the road with the message that speeds may be controlled. Of course, it is important that the information provided about enforcement actions is correct. Just saying that enforcement will take place without actually doing it may work for a short while but will quickly lose its effect and undermine future enforcement efforts.

Secondly, it is important to use publicity and information to explain the reasons for speed enforcement and highly desirable to give feedback on the safety effects and benefits achieved. This will help encourage public acceptance of speed enforcement and make the effects more sustainable. The information can be provided at a general level, by coverage in the media or by brochures. Locally targeted information with examples from known traffic situations has proven to be more effective than more general and less targeted information. When the enforcement is organised in such a way that the police apprehend the violators, this is another opportunity to inform the speeding community about what is being done to address the problem.

Box 9.1. **New enforcement policy in the State of Victoria (Australia)**

In 2002, a Ministerial forum was held in response to the Victorian road toll of 444 in 2001, the highest for 10 years. The forum identified that radical actions needed to be implemented immediately and launched the *Arrive Alive!* strategy, with a strong focus given to behavioural change programmes, such as speed enforcement. Key initiatives for the speed enforcement component of *Arrive Alive!* Included:

- Increased attention to “lower level speeding” (*i.e.* reduced tolerance threshold).
- Intensifying enforcement efforts – more hours for the mobile camera programme, more fixed cameras and a trial of section control.
- Making enforcement more unpredictable – including implementing “flash less” mobile cameras and a mix of marked and unmarked vehicle.
- Reviewing the speed camera strategy.

The Victorian Auditor-General’s 2006 review of Victoria’s speed enforcement programme considered inter-alia whether the speed enforcement programme had been effective in reducing speed and road trauma; and whether the programme was focussed on reducing risks rather than raising revenue.

The review concluded the programme had been very effective. In 2005, for the first time, average travel speeds in metropolitan Melbourne’s 60, 70 and 80 km/h speed zones were below legal speed limits. However, in 100 and 110 km/h speed zones across the State, compliance with speed limits had not improved. In each of these zones, around 15% of motorists still travelled at speeds above the speed limit.

The review noted that, in common with all fine-based enforcement programs, the speed enforcement programme undoubtedly raises revenue. However, the report demonstrated that revenue raised through speed infringements is still significantly lower than expenditure on road safety. Speed enforcement activities were underpinned by strong evidence and primarily directed at reducing road trauma, rather than raising revenue. One of the strategies adopted was to make enforcement more unpredictable.

Arrive alive! sets ambitious targets aiming for a 20% reduction in deaths and serious injuries by 2007. During the first four years of the strategy (2002-2005), there has been a reduction of around 16% in fatalities. In August 2006, Victoria reached its lowest fatality level over a 12 month rolling period.

Road accidents are multi cause; it is therefore difficult to conclude that the reduction in road trauma is solely due to improved compliance with speed limits. However, the greatest reductions in trauma have been in the lower speed zones, which are the most intensively enforced. There have also been significant reductions in pedestrian trauma and severity of serious injuries – two measures sensitive to changes in travel speeds. These factors suggest that improved compliance with speed limits has been a major contributor to trauma reductions.

Source: Auditor General Victoria (2006)

9.5. Instruments and systems for speed enforcement

9.5.1. Conventional speed control

Conventional or manual speed control usually involves a stationary observation unit (a marked or unmarked police car) equipped with a speed measurement device and, further down the road, another police unit to stop the identified car and to issue a fine to the driver. The measurement device may be a radar with Doppler effect or a laser device (*e.g.* laser binoculars).

The effects of this type of manual enforcement on speed and accidents have not been sufficiently studied. However, it can be argued that, compared to automatic enforcement systems (see below), the advantage of manual enforcement is that speeding drivers are stopped by the police. This allows for direct transfer to the individual of information about the reasons for enforcing speed violations. In addition, the intended time gained by speeding is immediately lost because of being stopped. Furthermore, the enforcement action becomes clearly visible to other road users. This increases the general deterrence effect of enforcement (Figure 9.1). With manual enforcement, it is possible to target different types of vehicles (which may be subject to different speed limits). The disadvantage, however, is that manual systems require a large amount of manpower and for this reason they are not a very cost-efficient approach.

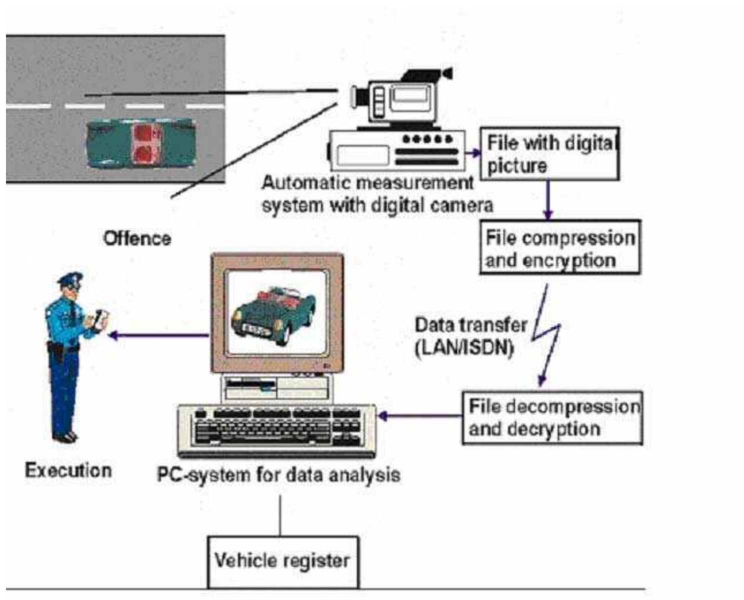
A video camera (and laser or radar) in a moving police car is another possible form of manual enforcement. The cars involved, often unmarked police cars, drive around the enforcement area and police take action when they see a major infringement, such as extremely high speeds, dangerous overtaking, close following, red light running etc. The violator is then followed and stopped. The video is used to confront the driver directly with his/her traffic behaviour and the police can then explain the potential consequences of this behaviour. Again, quantitative evaluations on the effects are lacking. The cost-efficiency is supposedly lower than for the stationary manual systems. Since the police car moves in the same direction and with approximately the same speed as the overall traffic stream, the chance to actually detect a violator in the direction of travel is relatively small. The video pictures are sometimes used for road safety television programmes, which enlarges the potential "audience".

9.5.2. *Automatic speed control*

Automatic speed control is performed without the presence of a police officer. The basic functions of such speed control approaches generally include (see Figure 9.3):

- On-site detection of a traffic offence.
- On-site registration of a traffic offence.
- On-site registration of the number plate of the vehicle.
- Transfer of recorded information to a processing system.

Figure 9.3. **Operational framework of automatic speed control**



Source: VERA

In some systems, the driver is informed by means of an electronic sign alongside the road of the presence of an automatic control. With more advanced systems, a large part of the follow-up activities are automated as well, including:

- Identification of the vehicle owner.
- Sending the violation notice (speeding ticket) to the vehicle owner or the driver (as identified by the vehicle owner).
- Tracking fines that have not been paid.

Contrary to manual speed enforcement, the manpower needed to perform automatic speed enforcement is very low, even more so if the information processing is automated. Furthermore, the probability of detecting and fining speed violators is substantially larger. This makes automatic speed enforcement a very cost-effective measure, even though the initial investment costs for the equipment are considerably higher than those for manual speed control. Moreover, road users perceive automatic speed control as more "objective" (Mäkinen *et al.*, 2003). Disadvantages of automatic enforcement include the lack of personal communication with the violator and the vandalism that is committed on automatic cameras.

The most well known and widely used automatic speed enforcement system is the fixed speed camera. Less common, but based on the same principles, is the mobile speed camera. Fairly new and less widely used are systems that measure the average speed between two points: *i.e.* section control. Each of these systems is discussed below.

Fixed and mobile speed cameras

A large number of countries all over the world use fixed speed cameras for their speed enforcement, both inside and outside urban areas. The cameras are usually located at road sections or intersections where speed is considered to be a problem. In some countries, *e.g.* Australia, the Netherlands, Switzerland, the United Kingdom speed cameras at intersections can be combined with the detection of red light running. Some of these devices include dummy cameras (there is no real camera inside the device) which are only used for deterrence effects (see section 9.5.3 below). Mobile speed cameras work much like fixed speed cameras. The main difference is that the camera can be moved around in the network. This increases the deterrence effect due to the unpredictability of the exact location of speed enforcement.

The effectiveness of speed cameras has been extensively evaluated. The large majority of these studies show positive effects on both the level of speeding and the number of (injury) accidents. The exact effects as reported in evaluation studies, however, differ widely. This depends among other things on the type of road, the initial safety situation, the initial level of speeding, the location of the speed camera, the road length taken into account, and last but not least, on the research method. Elvik & Vaa (2004) report on a meta-analysis of the combined results of 10 individual, methodologically sound studies in the period 1984-1996. This analysis showed that when all accidents are considered, automatic speed cameras are associated with a 19% accident reduction. In urban areas a 28% reduction was found and in rural areas a 16% reduction[7] on roads that were equipped with fixed speed cameras.

Many of the more recent studies show very similar results (see Goldenbeld *et al*., 2005) and a few studies may show even larger effects. For example, in Australia, a very intensive speed enforcement programme with mobile, inconspicuous speed cameras was associated with a 41% reduction in fatal accidents. The enforcement programme was supported by speed-related mass media publicity (Cameron *et al.*, 2003). In the UK, Gains *et al* (2005) evaluated the safety effects of the national safety camera programme (speed cameras in combination with red light cameras) and estimated a 42% reduction in killed or seriously injured casualties at the camera sites.

Sometimes people refer to the adverse effects of this type of fixed speed cameras in terms of sudden braking just before a camera and subsequent acceleration after passing the camera: the so called ‘kangaroo-effect’. This may increase the probability of a collision and also affect exhaust emissions. There are, however, few empirical studies that looked into these potentially negative effects of fixed speed cameras.

It should also be mentioned that fixed cameras do not (yet) distinguish between passenger cars and heavy vehicles. Therefore, when there is a differentiated speed limit for heavy vehicles, the cameras can not detect whether trucks are travelling in excess of the lower speed limit applicable to trucks. Furthermore, fixed cameras do not take into account any changes in speed limit due to changed weather conditions.

7. The results published by Elvik & Vaa in 2004 actually mention a 4% reduction in rural areas. However, recent recalculations of the rural area data revealed that this was incorrect and that the actual reduction in rural areas was 16% (Vaa, 2005; personal communication).

Box 9.2. **The automatic speed camera programme in France**

In France, the implementation of automatic speed cameras started in the second half of 2003. In July 2005 there were almost 450 speed cameras, both fixed and mobile, and there will be around 1 500 cameras by the end of 2007. The rate of deployment is therefore very fast. Approximately 75% of the speed cameras are located in rural areas and 25% in urban areas.

Implementation of Speed Cameras in July 2005

30 km/h	2	0.5%	Urban (21.1%)
50 km/h	44	10.1%	
70 km/h	46	10.5%	
80 km/h	12	2.7%	
90 km/h	246	56.3%	Rural (76.4%)
110 km/h	66	15.1%	
130 km/h	10	2.3%	
N/A	11	2.5%	
TOTAL	**437**	**100%**	

The enforcement process is fully automated from detection up to issuing fines.

It was estimated that, on average, each driver was checked 7 times a month, by fixed speed cameras by the end of 2005. The proportion of violations in relation to traffic varies considerably between locations; a number of speed cameras display higher than average detection rates, which suggests they have been placed on sites where the speed limit is not suited to the local conditions, or is ill-understood by drivers.

The results have been very positive in terms of speed reduction and accident reduction.

Local effects

The proportion of offenders decreased by a factor ranging from 6 to 30, according to sites, in the immediate vicinity of fixed speed cameras. Injury accidents and fatal accidents decreased by respectively 40% and 65% over the 6 km stretches of road centred on fixed speed cameras. This was much higher than the decrease observed at national level during the same period (19% and 28%).

Global effect

The average speed on French roads decreased by 5 km/h over three years. The rate of very severe violations (more than 30 km/h) was divided by 5. It is interesting to note that speeds already began decreasing with the announcement of the automatic speed control programme, even before the first speed cameras were actually installed. Between 2002 and 2005, fatalities decreased by over 30% in France – an unprecedented result. These substantial decreases are not entirely due to the implementation of automatic speed controls, but it largely contributed to them. It was estimated that the decrease in speed, in which automatic speed control played the major role, accounted for roughly 75% of this decrease.

Economics of the system

The government has been spending about EUR 100 million per year on investment and operational costs. It is estimated that, when all cameras will be operating, revenues generated by fines will amount to around EUR 375 million per year. A crucial element for the success of the speed camera programme is to have a transparent communication on the allocation of the revenues which are mainly invested on road safety improvements. It should also be noted that reduced speeds due to speed controls led to petrol savings, which substantially reduces government profit from the Tax on Petroleum Products.

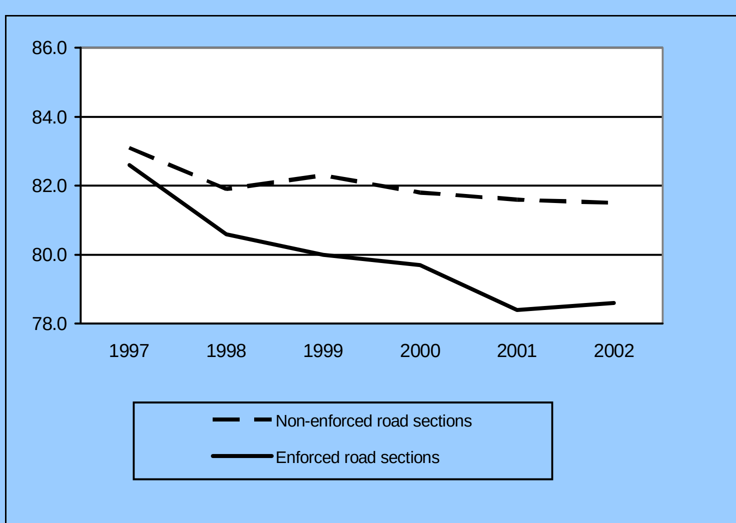
Source: Chapelon and Sibi (2006), Canel and Nouvier (2005).

Box 9.3. **A regional speed enforcement project with mobile cameras in the Netherlands**

The enforcement activities in the Netherlands were directed at rural non-motorway roads with a high number of injury accidents based on the police accident registrations from 1992 to1996. A total of 28 road sections with a total length of 116 km were identified as having a high accident level and were subjected to the targeted enforcement. The speed enforcement was undertaken with mobile radar equipment from an inconspicuous car. On average, there were one to two hours of speed checks weekly on each of the selected roads. On each of the enforced roads a special, posted road sign warned drivers that speed camera enforcement was possible, independent of the actual presence of enforcement. There were no signs to inform the driver that he/she had actually been exposed to speed enforcement. The roads where enforcement took place were also repeatedly mentioned in the local press and intensive information and publicity supported the enforcement activities.

An evaluation study was undertaken covering 5 years of enforcement and including speed and accident data on both the enforced roads and similar non-enforced roads. The speed data showed a significant decrease in mean speed and the percentage of speed limit violators over time. The largest decrease was found in the first year of the enforcement project (1998) and in the fourth year of the project, when the enforcement effort was further intensified (2001). There were also indications of spill-over effects: the speed also decreased at the nearby comparison roads that were not subjected to the targeted speed enforcement project. The best estimate for the safety effect of the enforcement project is a reduction of 21% in both the number of injury accidents and the number of serious casualties. This was based on comparisons between the number of accidents during the enforcement project (5 years) and the 8 preceding years on the enforced roads and at all other roads outside urban areas in the same region (see Figure 9.4).

Figure 9.4. **Mean speeds on enforced and non-enforced 80 km/h roads in the period 1997-2002 in the Netherlands**

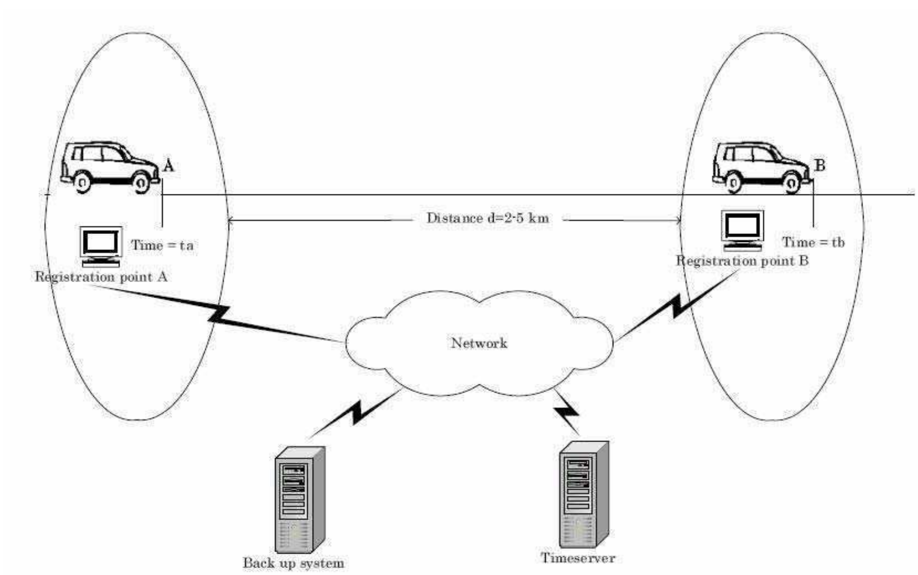


Source: Goldenbeld and Van Schagen (2005)

Section control

A fairly new approach to speed enforcement is called "section control" or "point-to-point control". Section control systems measure the average speed over a section of road (usually 2 – 5 km). The principle is quite simple: the vehicle is identified at the entrance of the enforcement section and again when leaving it. The average speed can be calculated based on the time between these two points. The information on those vehicles that travelled too fast is filed and processed (see Figures 9.5). Section control is normally carried out on stretches of road without entrances or exits, gas stations, parking areas, etc. The system could also be used for longer stretches, for example between the entrance and exit of a village or in 30 km/h zones, even though in that case, only the travel time of those vehicles that travel directly between entrance and exit point will provide meaningful information. Speed of those who do not take the direct road is of course underestimated.

Figure 9.5. **Schematic outline of the section control technique**



Source: Norwegian Public Roads Administration

Figure 9.6. **Section Control in the Netherlands**

Source: Stoelhorst, 2005

At the moment, speed enforcement by section control systems is being undertaken in Australia, Austria, the Czech Republic, the Netherlands, Switzerland and the United Kingdom. The first experiences in the Netherlands are very positive with very few vehicles exceeding the speed limit as well as more homogeneous speeds (RWS, 2003). In Austria, the section control system in the Kaisermühlentunnel near Vienna resulted in a reduction of the average speed, with only 0.5% of the traffic in excess of the speed limit and no serious accidents have occurred since the system was installed (ETSC, 2005). Drivers need to be warned in advance of a section control area to avoid sudden braking manoeuvres and subsequent congestion.

There are some specific legal issues that may block the implementation of section control in some countries at this moment. One such issue is related to the fact that average speed is not always recognised as a legal measure for speed enforcement. For example, France does not currently allow average speed as a legal measure, but at the initiative of several motorway companies, the systems were implemented on an advisory basis. Another issue is related to privacy laws, which do not allow information of non-violators to be registered. With a section control system, initially the information of *all* vehicles is registered, even though only the information of the violators is actually stored and processed.

9.5.3. Some general technical and legal issues related to automatic enforcement

Legal responsibility of driver or vehicle owner

Driver or owner responsibility for the offence is a key issue in automatic speed enforcement. In some countries (*e.g.* Finland, Germany, Norway, Sweden and Switzerland) *only the driver* can be held responsible for speed violations. In other countries (*e.g.* Belgium, France, Italy, the Netherlands, Portugal, the UK), *the registered owner* of the vehicle is held responsible for the offence, unless the vehicle or the licence plate has been reported stolen or if the owner provides the identity of the driver.

In Australia, the registered operator of the vehicle is responsible for the infringement unless he/she nominates another person as the driver and that person accepts the liability for the offence. The registered operator is the person who is recorded in the registration and licensing system for a vehicle. It is not necessarily the owner.

The legal system in force has consequences for the technical system of the automatic enforcement. In countries where the vehicle owner is legally responsible, it is sufficient to have a picture of the licence plate. In that case it is technically easier to capture the rear licence plate. In countries where the driver is legally responsible, one generally needs a picture of both the licence plate and the driver. Technically, this is more difficult and, in addition, more expensive. Registering the rear licence plate also has an advantage with regard to motorcycles, since they only have a licence plate on the rear. There is however a disadvantage with regard to lorries with trailers, as the trailer does not have the same licence plate (nor necessarily the same owner) as the lorry.

To apply a system which tickets the vehicle owner is technically easier and cheaper. In addition it substantially simplifies and accelerates the settlement of the sanctions and consequently diminishes the administrative burden involved. In countries that apply a demerit points system (see section 9.6), the vehicle owner would have the choice to provide the name of the driver, or to accept the penalty points him/herself. In many countries, an approach based on the legal responsibility of the vehicle owner will require changing the law.

The use of dummy cameras

Installing and operating speed cameras at all high-risk sites would be a very expensive operation. To solve this cost problem, many countries use “dummy cameras”. A dummy camera looks just like the real camera box, but has no camera or film inside. The installation costs of the dummy camera are about one-third of the costs of a real camera and the operating costs are also very low. The idea of dummy cameras is that drivers do not know whether the camera box actually contains a camera and they will adapt their speed "to be on the safe side". The effect can be strengthened by regularly rotating the operational cameras between the camera boxes as is done in many countries. In some countries, *e.g.* France, dummy cameras are not used for policy reasons.

Cross border enforcement

International road traffic continues to increase and with that the road traffic violations committed by foreign drivers are also increasing. There are indications that foreign drivers are over-represented in the sense that they commit more violations than would be consistent with their share of the traffic. For example in France, at the very beginning of the implementation of the automated enforcement programme, foreign drivers accounted for approximately 10% of the traffic, but for almost 25% of the offenders (Canel *et al.*, 2005).

Other problems related to cross border enforcement are violations committed by international goods vehicles and international coaches. In February 2005 the European Traffic Police Network Organisation (TISPOL) launched a European Roads Policing Operation targeting international coaches and buses. Fourteen European countries participated. During the operation 23 932 buses and coaches were stopped and checked; 6 889 offences were detected and 946 of them were speeding offences (TISPOL, 2005).

Currently, it is often very difficult or even impossible to prosecute the violations committed by foreign drivers. A major problem concerns the exchange of data of vehicles which commit a violation, and this has both legal and technical aspects. Only a few countries have mutual agreements for co-operation, *e.g.* in the Nordic countries (Norway, Sweden and Denmark) or between France and Luxembourg and France and Germany. Other similar agreements are under consideration in Europe. To achieve effective cross-border enforcement, each country must accept another country's record of a violation as well as its processing and sanctions. This mutual acceptance appears to be difficult to achieve, given the first European Convention dates from 1964. However, recently the European Union approved the Council Framework Decision 2005/214/JHA, of 24 February 2005, on the application of the principle of mutual recognition of financial penalties, which covers fines imposed for road traffic offences.

Cross border enforcement was the subject of two subsequent projects co-financed by the European Commission: VERA 1 (1998) and VERA 2 (2004) (see http://veraprojects.org/). The projects focused on the harmonisation of enforcement across EU Member States. It is generally accepted that the country where the violation took place should be responsible for the legal process and the country where the vehicle owner/driver is resident should be responsible for enforcing the penalty, if required by the country where the offence was committed. The VERA projects recommend that the vehicle owner should be responsible for the offence, unless (s)he identifies another person as the offender or provides proof that the vehicle had been sold, stolen or transferred. The projects identified a number of issues that have to be solved:

- The identification of vehicle nationality from the vehicle registration plate.
- Access to owner/driver information.
- Cross-border enforcement of non-financial penalties.
- Type approval and certification, including certification of speed enforcement systems using digital images.

Technical and practical tolerance levels

Speed detection devices may have some inaccuracy when measuring speeds. To prevent false alarms due to inaccuracy of the measurement devices (measuring a speed above the speed limit, whereas the actual speed was at or below the limit), a technical tolerance level is applied.

In addition to the technical tolerance, some countries also apply a practical tolerance: the radar is adjusted in such a way that small speed violations are not recorded. Currently, the tolerance levels differ from one country to another, with some applying only a technical tolerance and others adding a practical tolerance. In many countries, speeds are enforced some 10 km/h or more above the posted limits.

The problem related to high levels of tolerance is that they induce drivers to believe that a little bit of speeding is acceptable and that speed limits are not very strict. In recent years in Melbourne, Victoria (Australia) levels of enforcement have been increased, while the tolerance level has decreased. This resulted in a better adherence to speed limits and a subsequent downward trend in the road death toll (see box 9.4).

Application of a practical tolerance level is not recommended. In order to account for possible technical inaccuracy a 5% tolerance level seems to be appropriate. In any case, tolerance levels should not be lower than the legal error according to international standards.

Box 9.4. **Experience in Melbourne with tougher enforcement including lower tolerances introduced in 2002**

In Victoria a comprehensive campaign targeting speed and speeding was a key element of the Government *'arrive alive!'* 2002-2007 Road Safety Strategy. Between May and September 2002 Victoria Police introduced progressively a lower enforcement tolerance for all automated camera enforcement across the State. Enforcement levels had traditionally been set at 10 km/h above the relevant speed limit.

Levels of infringements increased concurrently with the lower tolerance levels (infringements levels in fact doubled). At the same time fatalities started to fall in Melbourne. By the end of 2003 infringement levels had returned to earlier (lower) long term levels and fatalities had fallen substantially in Melbourne.

The 43% reduction in fatalities in metropolitan Melbourne from 2001 to 2003 was spread across all road user categories. Other speeding deterrence measures introduced by legislation and regulations at the end of 2002 were:

- Lower speeding thresholds for increases in demerit point penalties
- Immediate licence suspension if detected 25 km/h over the speed limit (previously 30 km/h).

In the three years to the end of 2004, there was a 22% overall reduction in fatalities across all of Victoria, due to a range of initiatives including infrastructure safety programs, tougher drink driving measures, lower speed limits in higher pedestrian activity areas, annual demerit point limits for probationary drivers and tougher speed enforcement and penalties.

Radar detectors

The increase in automatic enforcement in many countries has resulted in the development of in-vehicle equipment that detects or shows the presence of an operational speed camera in advance: the radar detector and digital maps. Such radar detectors should be prohibited, as is already the case in some countries.

Digital maps can only take into account the fixed cameras (although the most frequent locations of mobile cameras can also be indicated); hence the interest in having a large proportion of mobile cameras, providing that they are installed at sound locations.

9.6. Sanctioning speeding violations

9.6.1. Categories of sanctions

As indicated, enforcement is based on the principle that people try to avoid a sanction. Hence, for the integrity of the enforcement system, when a violation is detected, it must be followed by a sanction. It is essential that the actual violators do not escape without sanction. The sanctioning system must be good and fair. There are different categories of sanctions.

Fines

The most common sanction for a traffic rule violation is a monetary fine. All countries apply fines to speeding offences. In the vast majority of countries, the amount of the fine depends on the amount of speeding with a minimum and a maximum amount. Table 9.2 shows the amount of the fines for a speeding violation in a number of countries.

Table 9.2. **Monetary fines applied in different countries see Annex B for more details)**

Country	Fine for a speed violation of 9 km/h in Euros[8]	Fine for a speed violation of 19 km/h in Euros[3]
Australia (Victoria)	80	128
Canada (average 13 jurisdictions)	58	87
Czech Republic	10-30	10-30
Finland	The fine is indexed on the salary.	
France	If speed limit ≤ 50 km/h, 135 euros (reduced to 90 euros if paid within 2 weeks). If speed limit > 50 km/h, 68 euros (reduced to 45 euros if paid within 2 weeks).	If speed limit ≤ 50 km/h, 135 euros (reduced to 90 euros if paid within 2 weeks). If speed limit > 50 km/h, 68 euros (reduced to 45 euros if paid within 2 weeks).
Greece	30	30
Iceland	0	135
Korea	24	24
Netherlands	30	55-70
Poland	< 13	13-26
Portugal	60-300	60-300
Russia	—	1.50
Sweden	84-106	127-148
Switzerland	39-77	116-155 (prosecution if urban areas)
United States (Florida)	21	84

8. Currency conversions were made with the European Central Bank rates effective on 19 October 2005.

In some countries the amount of the fine also depends on the location of the violation (*e.g.* urban areas, rural areas, motorways, working zones) or vehicle type (*e.g.* passenger cars/motorcycles, HGV/buses). In Finland, the fine is indexed to the salary level of the violator. This is, however, not specific to traffic fines, as in Finland all fines are tied to salary.

In some countries the fine is increased if not paid at once, and continues to do so the further along the system the case goes. If the offender wins the case, the fine is dropped, but losing the case means a much higher fine than paying right away. In some countries (*e.g.* France), the fine must be paid before the infraction can be contested, and the fine is reimbursed if the offender wins the case.

Withdrawal / suspension of the driving licence

For very severe speeding violations or in case of recidivism, many countries have the legal possibility to suspend or withdraw the driving licence for a particular period. Medical or psychological examination, participation in a rehabilitation programme, or a new driving test can be part of the procedure to regain the licence. The effect of suspension/withdrawal of the driving licence is primarily related to the restrictions on the offenders' mobility and subsequently on their lifestyle.

Demerit points

With a demerit points system, a detected traffic law violation results in a particular number of points, generally in addition to the "normal" sanction. If these points accumulate to a set number, a more severe sanction will follow (*e.g.* licence suspension, requirement to pass a new driving test, possibly in combination with participation in a rehabilitation course). The demerit points system differs from country to country. Some systems start at zero, adding points as violations are committed, whilst other systems start with a number of credit points, deducting points as violations are committed.

In some countries, novice drivers are allocated a smaller "reserve" of points, in comparison to experienced drivers, for one to three years following their driving test.

Among the countries that responded to the survey, demerit points systems are currently applied in Australia, Canada, France, Iceland, Ireland, Japan, Korea, Poland, the United Kingdom, Norway and the United States of America. The number of demerit points depends on the level of speeding, except in Ireland and the UK where the number of demerit points is higher if the driver is convicted by the court. In some countries (*e.g.* France), it is possible to recover some (but not all) of the lost points by participating in a training course.

A special case can be found in New South Wales (Australia), where a "double demerit point" has been applied since 1997: during public holidays the demerit points for speeding offences are doubled. In the 23 holiday periods (112 days) in which double demerit points were applied, there has been a 16% reduction in the number of fatalities compared to the same holiday periods before. One of the advantages of a doubling of demerit points is the relatively low cost involved. In 2001, the "double demerit point" was extended to other traffic offences and a survey showed that 89% of the population supported the initiative.

9.6.2. The effects of sanctions

Sanctions are an essential element of enforcement. Nevertheless, the effects of sanctions are a rather unexplored area in road safety research.

The most important requirement with regard to sanctions is certainty: if a violation is detected, it will be followed by a sanction (Goldenbeld *et al.*, 1999). The certainty of a sanction appears to be more important than the severity of the sanction, particularly if the chance of apprehension is small (Mäkinen *et al.*, 2003). A sanction is not necessarily a fine. A Finnish study (Mäkinen, 1990) indicated that a fine was not more effective than a warning letter sent by the police, suggesting that the fact that the police are involved may be more important than a monetary sanction.

Based on learning theories it is often argued that it is important that the delay between violation and sanction is very short in order to have an effect on the behaviour. However, there is no empirical evidence that tells us how short this period must be. Mäkinen *et al.* (2003, page 30) even state that "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".

With regard to the added value of demerit point systems there are some studies. However, it remains difficult to assess their effect in isolation, since they are often introduced as part of a larger package of road safety measures. An overview of the available literature indicated that the largest effects on road safety in general are to be expected immediately after the introduction of the system. If the chance of apprehension appears to be small, the effects extinguish rather quickly (Vlakveld, 2004; SWOV, 2005). At the level of the individual driver, there are indications that the effects are largest for drivers who are close to the threshold of the demerit points (Mäkinen *et al.*, 2003). To ensure the pedagogical value of demerit points, the driver must be informed of the sanction shortly after the infraction. Furthermore, it is important that the driver can easily check at any time the total number of points on his/her licence.

Regarding both fines and demerit points, it is important the sanction appears to be fair and applies in the same manner to everyone, without any discrimination or possibility to cancel the sanction.

9.6.3. Reward programmes

From psychological theories on learning and motivation it is known that rewarding good behaviour is at least as powerful as a behaviour modification tool as punishing bad behaviour. In road safety theories, rewarding has not received that much attention. However, research has indicated that it can indeed have a positive effect on traffic behaviour (Hagenzieker, 1999). Generally, the reward actions are part of a larger road safety programme, including targeted and general publicity as well as traditional police enforcement. Rewards vary from small tokens and vouchers to a chance of a bigger reward, *e.g.* a lottery ticket. Most of the reward programmes focus on seat belt wearing, since this is easy to detect. Rewarding correct speed behaviour is far more difficult to realise, since it requires constant monitoring.

However, modern technologies, in particular an Event Data Recorder or black box (see Chapters 7 and 10), are available that make it possible to monitor traffic behaviour automatically and over a longer period of time. In combination with GPS and a speed limit database it is now possible to monitor speeding violations using these technologies. As discussed in Chapter 8, a number of experiments have been or are being carried out using this equipment in combination with a reward programme. In some countries, for example, insurance companies offer cheaper premiums to drivers equipped with event data recorders. These applications generally take place outside the scope of the police, but they would also allow for a form of automatic policing which could then combine both the principles of punishing and rewarding.

It should however be highlighted that these programmes are difficult to implement in practice and there is not yet much evidence on their cost-effectiveness.

9.7. Cost-benefit of enforcement

It has been shown that speed enforcement can be a very effective means to reduce speed and accidents. The benefits of reducing the number of accidents, expressed as a monetary value, are high. Clearly, the exact benefits depend on the value that is attached to a statistical life, and personal and material damage. This differs between countries.

The costs of enforcement depend on the method of enforcement that is applied. Based on current experience, it appears that the overall costs of automatic enforcement are far less than the costs of manual enforcement. For example, in Finland, it was found that the operating costs of automatic enforcement were roughly 15% to 20% of the operating costs of conventional enforcement in comparable circumstances (VERA). The same magnitude of savings with automatic enforcement are found in France. The cost of enforcement (including cost of identification of the infringement and cost of processing the fine) is as follows:

- Manual procedure: EUR 80 / fine.
- Automatic procedure using fixed camera: EUR 12 / fine.
- Automatic procedure using mobile camera: EUR 32 / person fine.

In any case, the benefits due to reduced accidents are far larger than the operating costs. Elvik and Vaa (2004) report on two Norwegian studies that found a cost-benefit ratio of a speed camera programme of 1:26.7 and 1:8.9. Gains *et al* (2005) estimated a cost-benefit ratio of around 1:2.7 of the safety camera programme in the UK. Goldenbeld and Van Schagen (2005) estimate the cost-benefit ratio of a mobile camera programme in the Netherlands to be 1:3.

9.8. Policy considerations

Enforcement, if appropriately applied, is a very effective and cost-effective measure to reduce the incidence of speeding and to improve road safety. However, enforcement is not an end in itself. It is part of a speed management policy that ensures that speed limits reflect the function and characteristics of the road, that drivers always know what the speed limit is and are well informed about the effects of speed.

Adequate levels of traditional police enforcement and automatic speed control are needed, encompassing all road users (including foreign drivers) and all types of vehicles. For enforcement to be effective, it is important that it is seen to apply equally to all road users.

Automatic enforcement has many advantages compared to conventional enforcement. With the same resources the chance that speed violations are detected is much higher. A high chance of apprehension is essential for effective enforcement. Both fixed and mobile speed cameras can be used, the first requiring fewer resources and the second having the advantage of unpredictable locations for speed control.

Given its effectiveness, the development and use of section control (control of average speeds over sections of a road) should be pursued. It almost guarantees one hundred percent compliance, it results in more homogeneous speeds, and may be better accepted by drivers. However, automatic enforcement cannot entirely replace conventional enforcement, as the educational role of police is very important.

Randomness of enforcement is a major determinant of a driver's subjective assessment of risk of apprehension. Therefore, an "anywhere anytime" enforcement programme will have more wide ranging effects, especially if linked to publicity.

Minimising tolerances above speed limits is a key issue to be addressed and can improve the effectiveness of enforcement. Setting higher tolerance levels above speed limits gives a misleading signal to the drivers and makes the speed limit system less credible.

When a speed violation is detected, it must be made very difficult, if not impossible, for the violator to avoid the sanction. This requires an effective system to collect the fines. Furthermore, the processing of the sanction (fine or demerit point) should take the briefest possible time in order to increase the pedagogical effect. In the case of automatic enforcement, much of the settlement can be automated, starting with the identification of the vehicle owner through the national vehicles register. Making the vehicle owner legally responsible for a speed violation, as is already the case in many countries, makes the process cheaper and more efficient as well. Furthermore, moving the violation out of criminal law into administrative law allows for an almost completely automatic processing of detected violations and decreases the administrative burden of the judiciary.

Enforcement programmes must always be supported by good public communications including general and local publicity and information. These communications increase drivers' awareness of speed enforcement, increase the perceived risk of apprehension and, hence, increase the effectiveness of the enforcement. In addition, by explaining the reasons for speed enforcement, acceptance will be higher.

Of course, it is important to consult with all stakeholders as well as the community generally, prior to the wide implementation of an enforcement programme, as their adherence to the programme is a key element of success. In doing so, every effort should be made to ensure enforcement is not perceived as a revenue generating activity but rather as a critically important road safety function and an investment for road safety. Consequently it would seem appropriate and there may be public communications benefits in implementing arrangements that provide for revenues derived from fines to be reinvested in road safety work.

It should be stressed that the implementation of automatic speed control is not only a question of technical matters, even though those can be complex. Organisational and legal aspects are essential to the successful implementation of automatic speed control and in some countries, legislative changes may be required.

Last but not least, national governments should pay further attention to cross border enforcement of international drivers and penalties and implement bilateral or multilateral mutual recognition agreements, which allow drivers to be sanctioned in their home country if they violate a rule in a foreign country.

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CHAPTER 10.

FUTURE MEANS FOR DRIVER SPEED ASSISTANCE AND VEHICLE CONTROL

Driver speed assistance and vehicle speed control technologies are two of the major speed-related areas of current research and development across member countries. This chapter reviews current developments in this area. It first focuses on the different types of Intelligent Speed Adaptation (ISA) subject to research, development and testing in a number of countries. It then reviews other technological developments in member countries, including current research and development for longer term applications.

10.1. Introduction

Driver speed assistance applications and vehicle speed control technologies are two of the major speed-related areas of current research and development across member countries.

Transport administrations in many countries are exploring a range of *driver speed assistance* systems. A number of transport administrations are also exploring possible *vehicle speed control* technology applications. The systems under consideration by member countries independently fall under the generic technology description of “Intelligent Speed Adaptation” (ISA).

Considerable research and development is also being undertaken by vehicle manufacturers, primarily focussed on *driver speed assistance* technologies. A number of transport administrations are participating with vehicle manufacturers in joint projects. In Europe, the “Speed Alert” project is being undertaken with the involvement of equipment suppliers and transport administrations and with the support of the European Commission.

The United Nations Economic Commission for Europe (UNECE) Vienna Convention[1] establishes that “every driver shall at all times be able to control his/her vehicle”.

Driver speed assistance applications generally reflect these current philosophies under which the driver is fully in control of the vehicle and fully responsible.

Some of the *vehicle speed control* technologies currently being researched could allow some transfer of control over vehicle speed from the driver. While offering considerable safety potential, such vehicle speed control systems would require policy support and a shift from current thinking if they involve arrangements where drivers are not at all times “able to control his/her vehicle” *i.e.* drivers are not completely in control of their vehicles.

For this reason, a distinction should be made between *driver speed assistance* technologies on the one hand and *vehicle speed control* technologies on the other, even though options such as manual over-rides of vehicle control technologies can blur the distinction between the two. As well, it should be noted that, with the speed control technologies being tested, there is no intervention or speed change imposed as long as the driver is complying with speed limits. Importantly, in both groups, several new technologies are emerging that offer practical steps forward in speed management. Taken together, the technologies have the potential to greatly assist drivers in complying with speed limits and driving at appropriate speeds. The technologies also have the potential to greatly assist administrations in their efforts to reduce speeding and speed-related fatalities.

Given the interest of many administrations and researchers, there is a focus in this chapter on ISA technologies. The following sections highlight what ISA is, how it can be used, what the experiences are so far and what issues remain to be solved before it can be deployed at a large scale.

More detailed consideration is given to the EC SpeedAlert project in the section on “advisory ISA systems”. SpeedAlert is but one such approach to driver assistance; countries outside Europe are not necessarily pursuing exactly the same approaches to driver assistance applications.

Several other new technologies, which are also relevant for speed management but would need further development before they can be deployed in practice, are also discussed later in this chapter.

1. The 1968 Convention on Road Traffic, known as the “Vienna Convention”, standardises traffic rules and road signing among contracting parties of the UNECE.

This chapter therefore looks at the following developments:

- Intelligent Speed Adaptation.
- Other new technologies.
- New approaches to speed management.
- Policy considerations.

10.2. Intelligent Speed Adaptation (ISA)

Intelligent Speed Adaptation (ISA) is the generic name for advanced systems in which the vehicle "knows" the speed limit and is capable of using that information to give feedback to the driver or limit the maximum speed.

ISA technology aims to support the driver in adapting the vehicle's speed to the prevailing speed limit but can also be adapted to exercise control over vehicle speed. The ISA concept is very well developed. ISA systems have been subject to considerable research and development activities and have been successfully demonstrated in many countries.

ISA systems are strongly related to other new driving safety applications, such as systems for curve warnings, lane departure warnings, road surface and weather information, distance keeping, obstacle warnings, etc. The abbreviation ADAS – advanced driving assistance system – is often used for grouping these types of applications. ADAS systems are not the focus of this chapter but are briefly addressed in section 10.3.

Speed limiters, such as cruise control systems, provide an ISA-type of driver assistance and are generally supported by all countries. These technologies are currently available and have been reported on in the chapter on vehicle engineering (see Chapter 7). They are therefore not dealt with in this chapter.

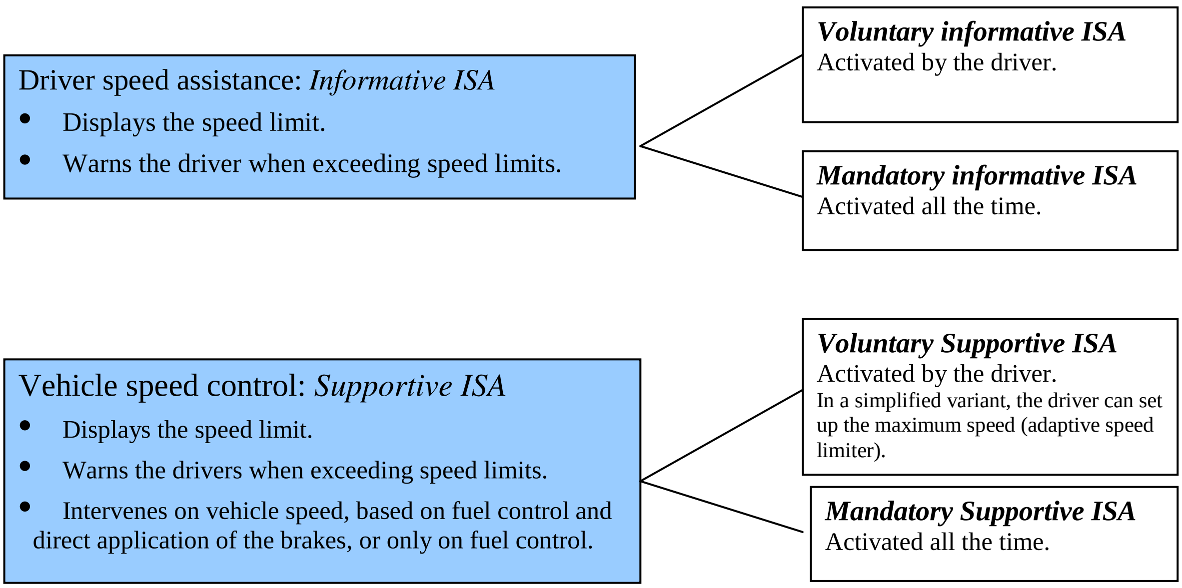
The two major categories of ISA systems – informative ISA (*driver speed assistance* technologies) and supportive ISA (*vehicle speed control* technologies) – are explored below.

10.2.1. The different types of ISA

Figure 10.1 illustrates the different types of ISA.

This is an advisory *driver speed assistance system*; it principally displays the speed limit and reminds the driver of changes in the speed limit by a visual and/or audible warning. Informative ISA can be activated manually by the driver or can be mandatory (with no possibility for the driver to switch off the visual or audible warnings). The European SpeedAlert project belongs to the category of Informative ISA.

Figure 10.1. **Different types of ISA**



Informative (Advisory) ISA

Some existing vehicle navigation systems now include functions that inform drivers of the prevailing speed limit and warn when the driver is exceeding the speed limit. However, to date, these systems do not rely on actual speed limit databases. They generally only give an indication of the likely speed limits, based on the road category.

Box 10.1. **The SpeedAlert Project**

The SpeedAlert project was jointly launched in 2001 by EU national governments and the equipment manufacturer industry, and is supported by the European Commission. The objective of the SpeedAlert project is to support the implementation of in-vehicle speed alert applications that can contribute to road safety. In order to achieve this general objective, SpeedAlert activities focus on the following specific objectives:

1. Establish a common classification of speed limits in Europe relevant to in-vehicle speed alert applications.
2. Identify the system and service requirements for in-vehicle speed alert applications.
3. Define functional architecture and analyse the corresponding technical building blocks.
4. Harmonise the definition of speed alert concepts and develop an associated deployment roadmap.
5. Identify requirements for standardisation.
6. Develop co-operation and liaison with other activities on the European and national levels.

The key principles agreed upon by the project stakeholders are that the driver is responsible for driving at a safe speed, that the system should be a speed limit information and warning system, and that fitting and use of the system should be voluntary.

First commercial speed alert applications are emerging on the market as extensions of existing navigation systems. However, there are still remaining issues that need to be resolved before a general pan-European deployment can be realised. One major issue is the procurement and update of speed limit data; this is more organisational than technical and requires strong support within transport policies at the EC and national levels. Some other issues are of a more technical nature (*e.g.* incremental map updating, infrastructure-vehicle communication) or are part of new initiatives (*e.g.* co-operative systems). In addition, vehicle manufacturers are concerned about legal aspects, liability, user acceptance and willingness to pay.

Source: www.speedalert.org

Supportive or intervening ISA

"Supportive ISA" is a vehicle speed control system. The system intervenes through managing the throttle (fuel supply) and sometimes additionally by acting on the braking system of the vehicle to reduce the speed of the vehicle if above the speed limit. A supportive ISA system can also be achieved by increasing resistance to depressing the accelerator when the vehicle is at or above the speed limit. This is known as the "haptic throttle".

Supportive ISA can also be activated manually ("voluntary" supportive ISA) by the driver or be compulsory ("mandatory" supportive ISA). Under mandatory variants, the vehicle is speed limited at all times. In a variant of voluntary supportive ISA, the driver can also set up the maximum limit, which is not necessarily the posted speed limit. This variant – also called adaptive speed limiter – operates without a speed limit database.

In all current developments, the driver can override a supportive or intervening ISA system in emergency situations.

Strictness

To date, speed-controlled cars have tended to use a 'haptic' pedal (*i.e.* an accelerator pedal that becomes harder to press the greater the excursion from the speed limit) as opposed to the direct application of braking. This configuration has some shortcomings: feedback is only provided when the driver's foot is on the accelerator pedal; deceleration may be very slow so that, on entering a slower speed zone, the vehicle could continue speeding for 0.5 km or even 1.0 km more; and the vehicle will be able to overspeed on downward gradients (Carsten *et al.*, 2003).

A "stricter" system includes interventions on braking. Recent research uses a combination of "dead throttle" and active braking. The initial retardation is achieved not through feedback on the driver's foot but by intervening between accelerator position and engine control (*e.g.* via a combination of ignition retardation and fuel starvation, but more ideally through a throttle-by-wire system). Additionally, a small amount of braking force is applied when the vehicle is a certain amount over the set maximum speed. If the onset of the retardation occurs *before* passing into a lower speed zone, the vehicle will comply with legal speeds at all locations.

Fixed / variable / dynamic speed limits

For both informative and supportive ISA, another dimension for differentiating ISA systems is that of the *currency* of the speed limits themselves (Carsten *et al*, 2003):

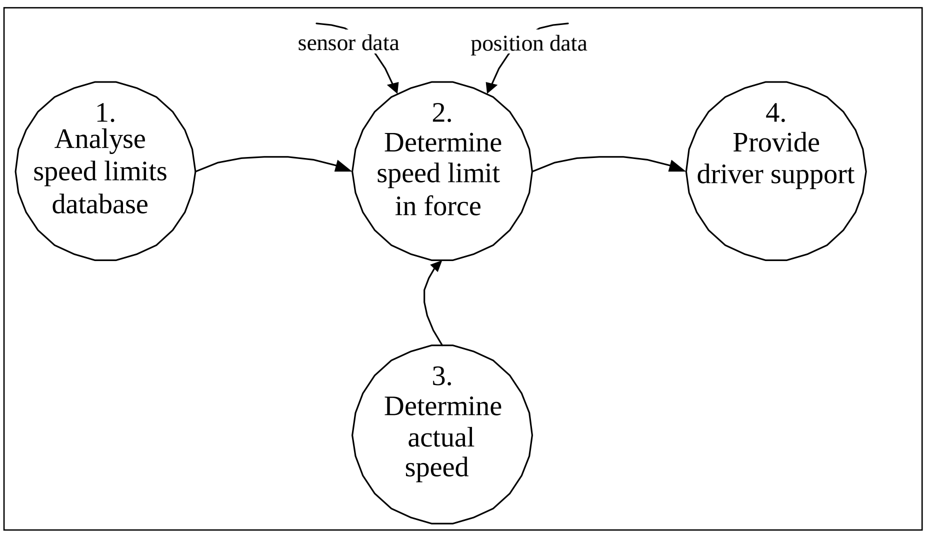
- *Fixed speed limits*: The vehicle is informed of the posted speed limits.

- *Variable speed limits*: The vehicle is additionally informed of variable speed limits (at road work zones for example).
- *Dynamic speed limits*: The vehicle is informed of limits that might locally change based on weather, traffic conditions, etc.

10.2.2. Core functions of ISA systems

Figure 10.2 shows the core functions and information flows in an ISA system. The purpose of each of these core functions is described below.

Figure 10.2. **Core functions and information flows in an ISA system**



Function 1: Analyse information from the speed limits database

Each ISA system needs to know the current prevailing speed limit. This is done through a speed limit database that includes the speed limit in force for each section of the road. Preparing and communicating this information to the vehicle are key elements in an ISA system.

The development of such databases falls under the responsibility of local or national authorities, as they are responsible for speed limits on the roads. Providers of digital maps used for navigation purposes have shown a great deal of interest in speed data, but primarily to improve navigation. They are, however, also candidates for participation in the provision of ISA services.

Function 2: Determine speed limit in force

ISA systems need to determine the vehicle position and direction of travel (*e.g.* by using a GPS system). The current speed limit can then be retrieved from a "speed map" database stored in the vehicle system. In more advanced ISA systems, additional information can be provided by vehicle sensors or roadside information systems providing local information in real time. If such additional information recommends a speed lower than the speed limit, the ISA system can take this into account.

Function 3. Determine actual speed

Actual speed is measured by the vehicle's speed measurement system.

Function 4. Provide driver assistance or support

The relation between the appropriate speed and actual speed establishes how, when and in what way the ISA system is activated.

The three latter functions (identifying the speed limit in force as established by the relevant authorities, determining actual speed and direction of the vehicle, and providing driver support) are generally developed by the equipment manufacturers.

Without standardised requirements mandated by appropriate standards-setting bodies that ensure consistent and compatible systems we cannot expect to see a generic ISA system or function. Different cars are therefore likely to have different ISA systems and the systems will evolve, meaning that old vehicles will have different ISA systems from new vehicles. It is, however, desirable that compatible systems be applied within the same world region, using interoperable speed limit databases. It is also desirable to have standards for communications of speed limit information to vehicles. This would enable the provision of support for cross-border traffic.

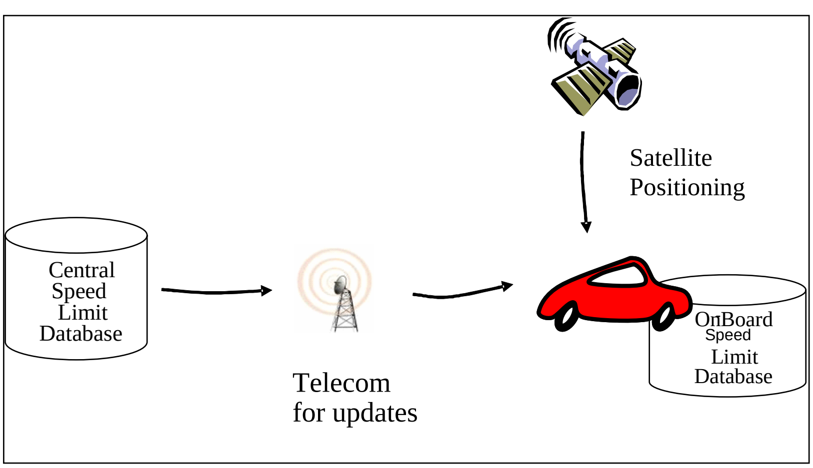
10.2.3 Technology options for ISA

The functions above can be achieved with several different technologies. The main alternatives are:

- ISA based on autonomous navigation (autonomous ISA).
- ISA based on roadside posts (dynamic or co-operative ISA).
- Combinations of 1 and 2.

In *ISA based on autonomous navigation*, the vehicle is equipped with an on-board system using navigation (*i.e.* GPS-based) to determine the speed limit at the current position. A local speed limit database is kept in the on-board system, based on information from a central speed limit database. Updates are downloaded using wireless telecom (Figure 10.3) or from a website. This concept means that all ISA-specific equipment is kept in the vehicle, and existing infrastructure is used for positioning and communication as may be the case. These systems cannot take into consideration variable and dynamic speed limits.

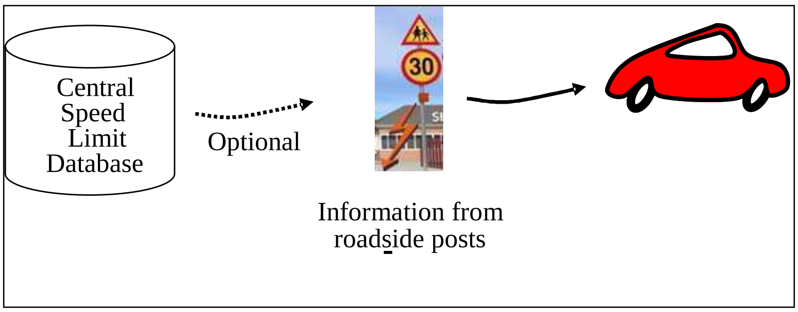
Figure 10.3. **ISA based on autonomous navigation**



Source: Stefan Myhrberg, SWECO

In *ISA based on roadside posts*, the vehicle receives the speed limit information from roadside posts (figure 10.4). In trial implementations, transmitters have been placed on sign posts, but an alternative would be to have transmitters in the vehicles, meaning that passive tags could be placed on the signs. Sign-based ISA needs a specific roadside infrastructure to supply the signs with information.

Figure 10.4. **ISA based on roadside posts**



Source: Stefan Myhrberg, SWECO

Combinations of ISA based on autonomous navigation and ISA based on roadside posts are also possible. Roadside posts can be used in certain areas and navigation in others. Alternatively, one of the technologies can be used for positioning and the other for updates. Combined technologies can bring better precision, reliability, coverage and ability to handle temporary speed limits, such as in work zones and more generally dynamic speed limits.

Until now, *ISA based on autonomous navigation* has been considered as the best solution when covering large areas, such as national and international implementation, as it is less expensive for the road authorities. New technology, for example passive transponders and video recognition of speed limit signs, or combinations of technology, might open up opportunities for new types of ISA implementation.

In a longer time perspective, ISA systems will probably be able to handle dynamic/variable speed limits due to weather, traffic, etc. This will increase the need for efficient real-time updates to the vehicles. Enabling services are currently being implemented. Some navigation systems are now able to suggest route changes based on real-time traffic information broadcast by subscription services provided in some regions.

10.2.4. Country attitudes

Almost all member countries support the installation and use of *informative ISA* systems.

Attitudes to *supportive ISA* systems are still evolving and vary among countries. Automatic control without any override capability would run counter to the current regulatory philosophy of drivers being fully responsible at all times – and the current culture among drivers themselves. Any proposed use of *supportive* ISA would raise political/public acceptance and liability concerns that would need to be addressed. However, it should be noted that, in all the supportive ISA systems under development, the driver always has the possibility to override the system (by a firm push down – or *kick down* – on the pedal) in emergency situations.

While recognising that supportive ISA systems would need further consideration, in principle the working group supports the careful consideration by governments of this option in view of its considerable potential to save lives. Carsten and Tate (2005) provide good support for this position although it should be noted this is based on accident analysis (see below) with a number of assumptions concerning driver behaviour and rule compliance.

10.2.5 Overall effects expected from ISA systems

ISA is primarily seen as a means for reducing road crashes, fatalities and injuries by reducing vehicle speed. By providing guidance to drivers or limiting vehicle speeds and harmonizing them (*i.e.* achieving a reduction in speed variation), fewer conflicts between vehicles will occur and the severity of accidents will be reduced. Reducing and harmonising road speed will also have a positive effect on the environment (*i.e.* reduced emissions of noise, exhaust gases, etc.) and on fuel consumption.

Overall safety effects

Recent simulation research in the United Kingdom concluded that the following reductions in fatalities shown in Table 10.1 could be achieved by the different types of ISA systems.

Table 10.1. **Fatal Accident Reduction Using ISA**

(United Kingdom)

System Type	Speed Limit Type	Best Estimate of Fatal Accident Reduction (%)*
Informative ISA	Fixed	18
	Variable	19
	Dynamic	24
Voluntary supportive ISA	Fixed	19
	Variable	20
	Dynamic	32
Mandatory supportive ISA	Fixed	37
	Variable	39
	Dynamic	59

Source: Carsten and Tate (2005)

* These figures are based on simulation and analysis of the speed distribution of traffic, assuming that 100% of the fleet is equipped with ISA, combined with accident analysis.

Safety effects from reduced speed

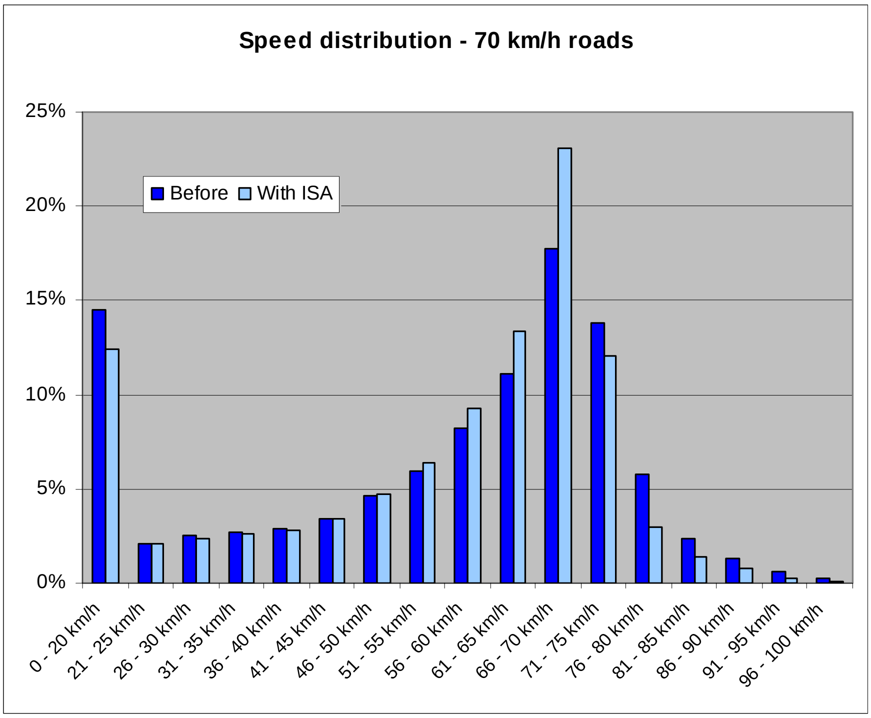
The actual safety effect from ISA applications will depend on the type of ISA system, the type of road environment (rural motorways, urban areas, *etc*.) and the penetration level of ISA equipment in the vehicle fleet. With only a few vehicles equipped, there may be an increase in overtaking movements, potentially inducing higher risks. When a critical proportion of the vehicles is driving with ISA, these vehicles will effectively reduce the speed of the rest of the vehicles in the traffic stream.

The broad safety effects from the introduction of ISA systems have been studied and estimated by Carsten and Tate (2005). The research results suggest that the mandatory use of a *supportive* ISA system that prevents drivers from speeding could bring about a reduction of serious accidents of up to 50%, while the voluntary use of an *informative* ISA system could result in a 2-10% accident reduction.

The overall conclusion from the ISA field trials in Sweden – with both informative and supportive ISA – was that ISA, if introduced nationally on a voluntary basis, may bring a reduction of serious accidents in the order of 20% (Biding *et al*., 2002). The efforts that have been put into development, experiments and demonstrations of ISA reflect the promising results from these theoretical studies and experimental results.

Figure 10.5 shows the actual measured effects on speed[2] of ISA (with easy overridable active throttle) used in trials in Stockholm (Sweden) in 20 vehicles.

Figure 10.5. **Speed distribution on urban 70 km/h roads with and without ISA**



Source: Myhrberg (2005)

Safety effects from reduced speed variation

Variation of vehicle speed in traffic flow is an important risk-inducing factor. Overtaking itself is a risk factor, and other safety risks also result from speed variations.

The benefits of reduced speed variation that can be expected to follow the implementation of ISA systems are included in the safety estimates above.

The implementation of supportive ISA systems that prevent speeding clearly would have an effect on speed variation, as all speeds above the speed limit are excluded in the case of mandatory ISA. This would create a platooning of vehicles at speeds close to the speed limit. During a transition period with low ISA penetration there could be negative effects due to speed variations between ISA-equipped vehicles and other vehicles.

2. The large share of driving at 71-75 km/h despite the use of ISA, is probably due to the fact that ISA-support in this trial was activated at 2 km/h above the speed limit. One also sees that, despite the ISA system, a number of drivers drive above the speed limit using the easily overridable active throttle.

Fuel savings

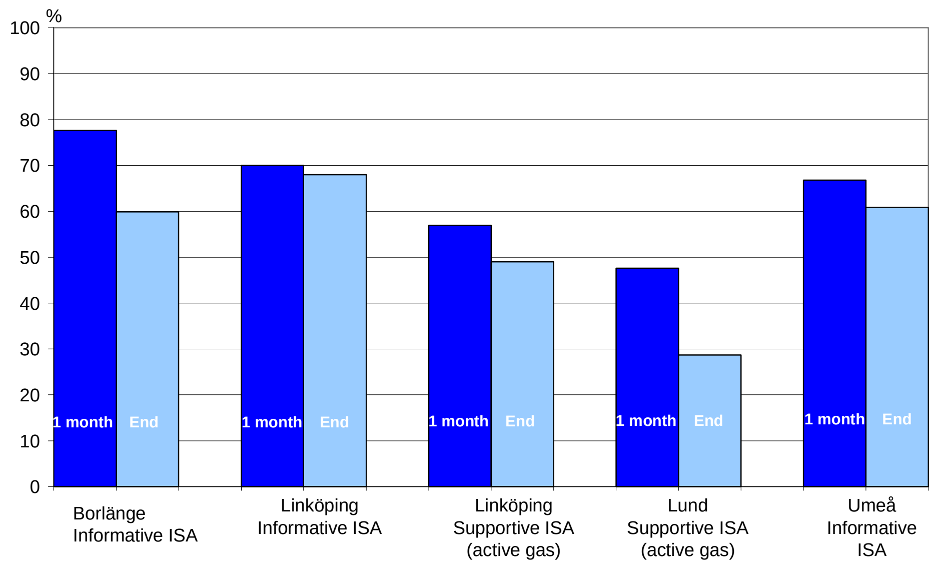
Reduction and harmonisation of vehicle speeds (with fewer speed changes) can be expected to have an important effect on fuel consumption (similar to the reduction achieved with eco driving). Model analysis, based on results from experiments (*e.g.* Liu *et al.* 1999), indicate that ISA applications could bring a reduction of fuel consumption ranging from 1% (on motorways) to 8% (on urban roads). In addition to these reductions, full scale introduction of supportive ISA could be expected to bring less disrupted traffic flows.

10.2.6. Acceptance and psychological factors

In most trials and questionnaires, the reaction to ISA has been mainly positive acceptance, especially for the *informative* ISA systems. In general, drivers who agreed to test the systems are more positive about ISA than the average driver. In the large-scale trials in Sweden (1999-2002) acceptance increased after having tried ISA, compared to stated opinion before. After long-term use, while drivers were a little less positive, most drivers wanted to keep the system, especially those having tested the *informative* versions (see Figure 10.6).

Figure 10.6. **The share of test drivers who would like to keep the ISA equipment after one month and following completion of the test period**

(Large-scale trials in Swedish cities 1999-2002)



Source: Biding,T. and G. Lind (2002).

10.2.7. Negative side effects of ISA

In addition to the potential negative effects during the transition period, other adverse side effects could occur:

- Speed compensation. Drivers may tend to drive faster in areas where ISA is not active, if such areas exist.
- Overconfidence. Drivers may rely too much on the speed limit indicated by the system, and not enough on real-time conditions.

- Behavioural adaptation. When forced to drive at a safer speed, drivers may pay more attention to other non-driving tasks.
- Frustration. Drivers may be frustrated by speed limitations or disturbed by speeding warnings from the system.
- Reduced inter-vehicle distances, which make it more difficult to enter or to cross traffic.

Some of these effects have been reported by a minority of test drivers in ISA trials, whilst others are hypothetical risks. Correct design of ISA user interfaces together with well-managed deployment issues could minimise these effects.

10.2.8. Other effects

It has been assumed that a general speed reduction will also bring longer travel times, which can be seen as an additional cost to using ISA. The effect is supported by model exercises, while some experiments (*e.g.* Biding *et al.* 2002) demonstrate unchanged travel times.

10.2.9 Recent and current trials and projects

Saad and Mallaterre (1982) carried out the first field trial in France in a car with a speed limiter - in the early 1980s. An in-car system was studied where the driver could set the speed limit, which could not be exceeded unless the driver disengaged the system. In the early 1990s several driver support systems were studied in the EC DRIVE I[3] project entitled Generic Intelligent Driver Support (GIDS). This included an active pedal that could increase its return force as a function of the excess of the prevailing speed limit. Since that time there have been a number of trials of a variety of technologies in European countries. Some of these are described below.

United Kingdom

The first major study of ISA in the United Kingdom was the External Vehicle Speed Control project which was funded by the Department of the Environment, Transport and the Regions (DETR) between 1997 and 2000. It studied acceptance of ISA, investigated technologies, and conducted user trials in simulators and in real traffic with a converted car.

A new set of four field trials began in August 2003, funded by the Department for Transport (DfT) and led by the University of Leeds. Each lasted for six months. Twenty vehicles (Skoda Fabias) were equipped with ISA and data collection capability for the field trials. The trials were designed to be non-intrusive – the vehicles behaved like "normal" cars apart from the ISA feature. Data were logged automatically and data collection was conducted remotely through a GSM link. The drivers were able to override the ISA system (through a push-button on the steering wheel), but the ambition was to give support for almost all regular driving. The technology worked well in the trials. Analysis of the speed change (compliance) actually obtained in the first of the four trials, with private motorists in Leeds, indicates that the average speed reduction obtained would translate into a 19.3% reduction in the risk of being involved in an injury accident on roads with a 50 km/h speed limit.

3. The DRIVE I Programme is the EC-funded Dedicated Road Infrastructure for Vehicle Safety in Europe (DRIVE) Programme.

The UK projects have also included simulations to evaluate network effects. One outcome was that 60% of ISA penetration could, under certain conditions, be sufficient to obtain significant results. Results from the UK have been focused on estimations of effects, cost/benefit studies and deployment issues.

In March 2006, the Mayor of London announced that Transport for London (TfL) will host a pilot of intelligent speed adaptation technology in London in 2007. The proposed pilot – which plans to equip 40 000 vehicles – will include fitting ISA technology in buses, taxis and local authorities' vehicles.

Sweden

The first Swedish field trials took place in Lund and Umeå in 1996-1997. Following that, during 2001-2003, 5 000 vehicles in four Swedish cities were equipped with different kinds of ISA systems, both informative and supportive. The supportive system is shown in Figure 10.7. The project was financed and managed by the Swedish Road Administration with specific support from the government. Drivers participated with their private vehicles and drove with activated ISA for up to two years. This long period gave researchers unique possibilities to follow how driver attitudes towards ISA could change over time.

Figure 10.7. **Components of active accelerator ISA from Swedish demonstrator**

Source: Biding, T. and G. Lind (2002).

The main findings were:

- Better road safety without increasing travel time.
- If everyone had ISA, there could be 20% fewer road injuries in urban areas.
- Relatively good acceptance of ISA, and after the trial most test drivers were of the opinion that ISA should be compulsory in urban areas.
- ISA vehicles were found to have a positive influence on surrounding traffic.
- Minor differences between the tested systems, with an average speed reduction of 3-4 km/h in stretches between intersections.
- The systems must be improved to become more attractive.

After the large scale trials, Sweden has continued its ISA work according to an action plan for increased national use of ISA. Speed limits for the entire road network are now available in the national road database. In 2005 vehicles belonging to the Swedish Road Administration were equipped with ISA (informative of supportive) with national coverage. Other ISA work is oriented towards increasing demand and supply of ISA, for both private and professional drivers, *i.e.* in transport procurements. The city of Stockholm installed active ISA in 20 vehicles in 2004.

The Netherlands

From October 1999 until October 2000, the Transport Research Centre (AVV) of the Dutch Ministry of Transport conducted a trial involving 20 passenger cars and one bus. The trial took place in an urban area of the city of Tilburg and three speed limits were used – 30, 50 and 80 km/h. When the vehicle exceeded the maximum speed limit for that area, the speed of the vehicle was adjusted automatically (the fuel inlet was automatically restricted).

Results show that user acceptance was high and predominantly positive, as was appreciation for driving test cars. Average speed decreased by 6.5 km/h on 30 km/h roads, and by 3 km/h on 80 km/h roads. Speed variation was decreased. However, mixing ISA cars with non-ISA cars caused some irritation (Van Loon *et al.*, 2001).

The Dutch Ministry of Transport also conducted the Belonitor trial in 2004 for a six-month period. Unlike other trials, this one used the concept of providing rewards in order to change or influence driving behaviour. Sixty-two vehicles were instrumented to monitor driving behaviour. The on-board equipment included a display unit, a calculating unit, a digital speed map, GPS, GPRS, and a radar sensor. The driver accumulated points if the speed limit was not exceeded and for maintaining a safe following distance to the vehicle in front. Results showed that the percentage of kilometres travelled within the speed limit increased from 68% to 86%, and from 58% to 77% for maintaining the proper following distance. There was also an average reduction in fuel consumption of 5.5%. However, as soon as feedback and the reward system ended, most drivers lapsed into their old habits.

Belgium

ISA was first introduced in Belgium by way of a large-scale questionnaire in 1998 about "the possible creation of an ISA system". Also, in the same year a first vehicle equipped with ISA ("active accelerator pedal") was introduced in Belgium. In October 2002, the first ISA trial started in Ghent, in association with the Belgian Institute for Road Safety, the City of Ghent, an insurance company, the provincial administration, Volvo-cars Ghent and the regional public transport company. The project ended in December 2003. Thirty-four cars and 3 buses had been equipped with the “active accelerator pedal” – 20 cars were voluntary users of the ISA-system (private drivers), while 14 other vehicles and 3 buses were used by companies and public administrations.

The test area included the entire city of Ghent, which contains all legislated speed-limits – 15 (pedestrian area), 30, 50, 70, 90, and 120 km/h. The system was turned on automatically every time a vehicle entered or started in Ghent and could not be turned off inside the test-area.

To date, results are based on questionnaires only – speed data has been logged but not yet evaluated. Test drivers declared that they were driving slower with ISA. Acceptance was good and 15 of 20 private drivers chose to keep the equipment after the trial.

More information can be found at: www.ISAweb.be.

France

The French LAVIA[4] project started in 2001 and uses two prototype vehicles and 20 fleet vehicles. The pre-assessment phase has been completed. Twelve accompanied drivers took part, driving around a well-identified route with the collection of video data and vehicle parameters.

The second phase took place in 2005 and involved 100 drivers who had free usage of the vehicle for an 8-week period. Users tested 3 operational methods (each for 2 weeks) – informative ISA; supportive ISA that can be disengaged; and supportive ISA that cannot be disengaged, except in case of emergency by a kickdown function. Data were collected and analysed and the main results will be published at the end of 2006.

Several lessons have been learned. First, the speed database is difficult to construct due to incomplete or ambiguous signposting and the need for up-dating. Second, the lack of relevance between the speed limit and the characteristics of infrastructure can influence the extent to which the system proves acceptable. A survey was undertaken before the trial amongst 1 000 drivers in the test zone. It showed 31% of answers in favour of the system and 23.5% against. Those undecided represented 45.5% of the panel. Lastly, preliminary results showed that the informative ISA has a limited influence on speed behaviour and that supportive ISA offers the most prospects of reducing speeding behaviour.

Another project (LARA) is being developed by motorway companies currently building a comprehensive speed limit database for their networks. The LARA database can be updated very quickly in case of roadworks or other events. The transmission of speed limits to cars is made through RDS-TMC, and the information can also be displayed on the on-board guidance units. In a longer time perspective, it is likely that ISA systems will be able to cope with dynamic/variable speed limits (due to weather, traffic, etc.) on all kinds of networks. This will increase the need for efficient real-time updates to vehicles (the RDS-TMC solution opens new avenues for this crucial issue).

Australian SafeCar

This trial, which was commissioned in 1999 by the Transport Accident Commission of Victoria (TAC), sought to examine behavioural adaptation and acceptance of four technologies – ISA, Following Distance Warning (FDW), Seat Belt Reminder (SBR), and Reverse Collision Warning RCW). Results showed that ISA was effective in reducing mean speeds, and even more so in reducing

4. LAVIA is the acronym for Limiteur s'Adaptant à la Vitessse Autorisée (Limiter which adapts to the authorised speed).

speeds at the higher end of the distribution, such as 85th percentile speeds. In addition, the ISA system appeared to be most effective in reducing speeding when combined with the FDW system (Regan *et al., 2005).*

Other sites and plans for future demonstrations

Following the success of the initial demonstrations, ISA field trials and demonstrations have also been carried out in Canada, Denmark, Finland, Japan and Norway

PROSPER

PROSPER (a Project for Research On Speed adaptation Policies on European Roads) is funded under the 5th Framework of the European Union's Research Technology Program and has participation from eight member countries (Belgium, France, Germany, Hungary, the Netherlands, Spain, Sweden and the United Kingdom). The objectives are to assess regional differences in effects on driver behaviour when driving with ISA in Europe and to investigate the driving behaviour effects from different kinds of ISA (informative/limiting, voluntary/mandatory – see Table 10.2.).

Table 10.2. **PROSPER Field Trials**

Country	Year of Trial	Size of Trial	ISA Variants
Belgium	2002-2003	37 cars, 3 buses	Supportive (AAP*)
Hungary	2003	20 cars	Informative and supportive (AAP)
Netherlands	1999-2000	20 cars, 1 bus	Mandatory supportive
Spain	2004	20 cars	Informative and supportive (AAP)
Sweden	2001	5000 vehicles	Informative and supportive (AAP)
United Kingdom	2004	20 cars	Mandatory supportive

*AAP = Active accelerator pedal

The results showed that the acceptance of ISA was fairly high among most test drivers in the various countries. ISA had its greatest effect on 30 km/h stretches, according to the test drivers in all countries. Most test drivers, except those in Spain and Hungary, stated that they were more positive towards ISA in several aspects after having tested it than before.

The effectiveness of ISA in reducing driving at excessive speed (*i.e.* over speed limits) was measured in all studies and all indicated large changes in speed limit observance.

MASTER

The EU co-funded MASTER (MAnaging Speeds of Traffic on European Roads) project, which was started in 1996, has as its aim to produce information that could be used for national and EU decisions concerning speed management and speed control equipment standards.

Summary

The field trials in Europe and Australia over the past 10 years indicate that:

- Potentially large increases in speed limit compliance are technically achievable and models indicate that this would result in significant decreases in collision rates and severity.
- The most effective ISA system has been shown to be the active accelerator pedal system; however, the audible system has been judged more acceptable to the user.
- Neither system was shown to interfere with other driving functions.

In summary, ISA has been found to be a very promising way to improve traffic safety, with positive side effects on the environment. High expectations from theoretical studies have, to a large extent, been confirmed in demonstrations and experiments, also showing strong support for ISA from drivers participating in experiments. A rapid development of ISA could be envisaged, even though the issues as well as the promising results need very careful consideration.

Informative ISA are already available in a number of trial vehicles in a number of different countries. While ISA systems have been under testing, commercial navigation systems have been improved and now include functions that inform the drivers when they are exceeding the likely speed limits. However, as these “likely speed limits" are not based on speed limit databases, but on the speed limits associated with the category of each road, the commercial navigation systems at this stage do not offer the same capabilities as an ISA system.

10.2.10 ISA deployment issues

Technology

Various systems architectures, user interfaces and technical sub-systems have been included in ISA field trials. In general, the systems have worked quite well and the results have met the expectations with regard to the user experience and reaction to ISA. However, the trials have one thing in common – they have been designed for local use.

The key technical issues arising from experiments with local use are the following:

- Establishing speed limit databases with sufficient coverage and quality.
- Updating speed limit information.
- Communicating speed limit information to the vehicle while it moves in the road network. In smaller scale experiments a local speed map can be stored in the vehicle equipment.

However, full deployment will require updated speed information to be continuously communicated to the vehicle. This will require providers of ISA equipment and speed limit information providers to agree on data formats and communication standards, etc. The current European *SpeedAlert* and *Euroroads*[5] projects are focusing on the issue of harmonization and distribution of speed information with a European perspective (*e.g.* Blervaque, 2003).

5. The objective of the Euroroads project is to build a platform for a European road data solution through a specification framework consisting of a road data structure, description of data content, data exchange mechanisms and interoperability specifications.

Scale

It is often assumed that even a small percentage of vehicles equipped with ISA will have a significant effect on the speed of traffic in general. In the Swedish ISA trials it was assumed that a penetration of 10% or higher would be sufficient to influence the speed of all traffic. However, recent studies including simulations of ISA in traffic networks (PROSPER) show contagion effects to be minimal, even at high ISA penetration levels. Most probably, this is due to the influence of traffic density where significant effects are only likely to be found when traffic is both dense and faster than the posted speed limit.

Organisation and market

The technology issues identified highlight interoperability as a key issue. ISA cannot reach large scale deployment without organisational structures supporting the application. The technique required is not particularly complicated, but roles and responsibilities must be defined and established to allow for development and operation.

Many car manufacturers were initially perceived to be somewhat against ISA, as presented in early trials. These perceptions are changing, as the ISA concept now also includes purely informative systems, and as aftermarket navigation system and speed camera warning systems are introducing competition in this field. Several car manufacturers are selling speed-limiters in which the driver can choose and set a maximum speed; this can be regarded as a first step towards an ISA function.

ISA attracts strong support from the drivers who have experienced it and we can expect a growing demand from customers, especially in countries with intensive speed camera programmes, in particular when mobile cameras are widely used.

Policy and legal issues

Analysis has shown that voluntary introduction of *informative ISA* will not cause any legal problems (Sundberg *et al.*, 2005). We have already seen a market develop for autonomous products and services quite similar to *informative ISA*.

Supportive ISA systems, on the other hand, which provide advice to the driver but also intervene via direct linkage to the vehicle control system, are more problematic. Current applications have a manual over-ride. Without a “manual” override function, *supportive ISA* systems would operate as mandatory vehicle speed control systems. We have not yet seen supportive ISA appear as a part of the control functions offered for new cars despite the fact that European and the national road safety policies of some countries are strongly in favour of the introduction of ISA. There are probably several reasons for this.

Firstly, speed limit databases are not yet available everywhere. Another reason may be that *supportive ISA* is legally more complicated if mandated for use. The key issue is not whether *supportive ISA* systems have the technical ability to “take control” of a vehicle, but rather the question of liability in the event of malfunction of the ISA system or if erroneous or outdated data is fed into it.

There is also an important difference in policy between vehicle manufacturers and authorities. Manufacturers are deeply concerned by the current discussion on the introduction of *supportive ISA* based on road information (*e.g.* speed limits) provided by authorities *i.e.* outside their own control. The manufacturers are not in favour of creating a system with such interdependency, and their concerns are discouraging them from taking even the first steps of introducing a first generation of simpler autonomous systems. It should be noted in this respect that a few countries (*e.g.* Germany) refuse any obligation to provide and certify speed limit data for ISA purposes due to legal and liability considerations.

Important practical reasons that also impinge on deployment can be found in the lack of standards for speed data provision (*e.g.* across Europe), and also a lack of available speed data itself.

10.3. Other new technologies

For the longer term, there are a number of other technological advances that can be expected to provide real opportunities to greatly reduce the number of collisions, and ultimately the number and severity of casualties.

It is of course essential that the impact of technology be fully tested and evaluated in development and in pilot projects on the road network before widespread rollout. As well as optimising their intended road safety benefits this will also identify any potential disadvantages. It is important to guard against the increased use of technology having the contrary impact and compromising safety, especially as such devices become increasingly complex or integrated with others. There will also be other important implications, including training requirements, financial cost and much wider issues, such as liability and social acceptability to overcome “big brother” concerns.

Many countries are already actively participating in research into Intelligent Transport Systems (ITS) and Advanced Driver Assistance Systems (ADAS). As an example, the European Commission's eSafety initiative was launched in April 2002 to co-ordinate these opportunities and seek to accelerate their development and deployment. Nonetheless it is essential that individual countries, and pan-European and world-wide forums continue to research and analyse these emerging opportunities so that informed decisions can to be made at the appropriate time.

The long-term vision is for intelligent highways where individual vehicles and roadside infrastructure communicate using a variety of different media. Bringing together various existing and future systems for the creation of such an intelligent highway would greatly assist drivers. It also opens up wider potential to actively control vehicles from the roadside from which it would be possible to reduce or even eliminate the margin for driver error through, for example, detecting other vehicles and obstacles in close proximity. Ultimately, technology could enable detection of road conditions simply through the level of adhesion between vehicle tyres and the road surface, while short-range communication systems could allow immediate dissemination of adverse conditions to upstream vehicles, allowing for proper speed adaptation.

The sections below summarise some of these projects.

SASPENCE

SASPENCE is a sub-project programme under the European Commission’s Integrated Project PReVENT[6], the main goal of which is to develop and evaluate an innovative system to ensure compliance with the Safe Speed and Safe Distance concept. This concept will be realised and tested in two demonstrator vehicles. The SASPENCE system is conceived to co-operate seamlessly with the driver, suggesting the proper velocity given the actual driving conditions (*i.e.* road condition, traffic

6. The Integrated Project PReVENT is a European automotive industry activity co-funded by the European Commission to contribute to road safety by developing and demonstrating preventive safety applications and technologies.

density, road geometry, frontal obstacles, potentially dangerous road locations, weather conditions, etc.). The system will suggest, and help the driver to keep to, the proper speed and headway, preventing risky and dangerous situations, and thus avoiding collision. SASPENCE will also provide the driver with useful support to lower lateral acceleration on inside curves to avoid potential loss of control of the vehicle.

SafeMAP—Digital information for safer driving

The SafeMAP project in the European Union combines public sector agencies and private sector firms and focuses on six assistance features, namely speed limit assistance, curve warning, intersection warning, overtaking assistance, hazardous area warning and accident spot warning.

Static and dynamic features of the roadway must be integrated into digital maps that then become part of the on-board navigation system provided in the vehicle. Static information includes speed limits, roadway features, geometrics, and so forth. Dynamic information includes accident data, weather conditions, construction work zones, and other data that change with time.

The system can warn drivers when the posted speed limit is exceeded. While the use of a static, digital map can be valuable to the vehicle operator, the combined effect of both static and dynamic information regarding the environment in which the vehicle is travelling will be a powerful application of the ITS technologies. Ultimately, SafeMAP will allow the driver to focus on key decisions that will be made with pertinent and timely information.

Galileo applications

The GALILEO satellite radio navigation system is an initiative launched by the European Union and the European Space Agency. This worldwide system will work in complementarity with the current GPS system. Application to road safety and speed management could include permanent monitoring of a car, or advising when the driver is travelling too fast. It could also warn drivers when they are approaching a bend too fast for example, if associated with a digital speed limit database. The greatest gains could be experienced by specific types of transport, such as the transport of dangerous goods.

Electronic Vehicle Identification (EVI)

EVI is an electronic vehicle plate, developed mainly to identify and find stolen vehicles. EVI allows high-level section control, meaning that it can follow a car for any distance.

With this system, it could also be possible to automatically calculate speeds for each vehicle, and to identify those driving above the speed limit on a section of road (section control) more easily than with current means. The fact that such a system is also useful for identifying stolen vehicles may well be an argument in favour of its introduction.

Identification of driver through digital print recognition

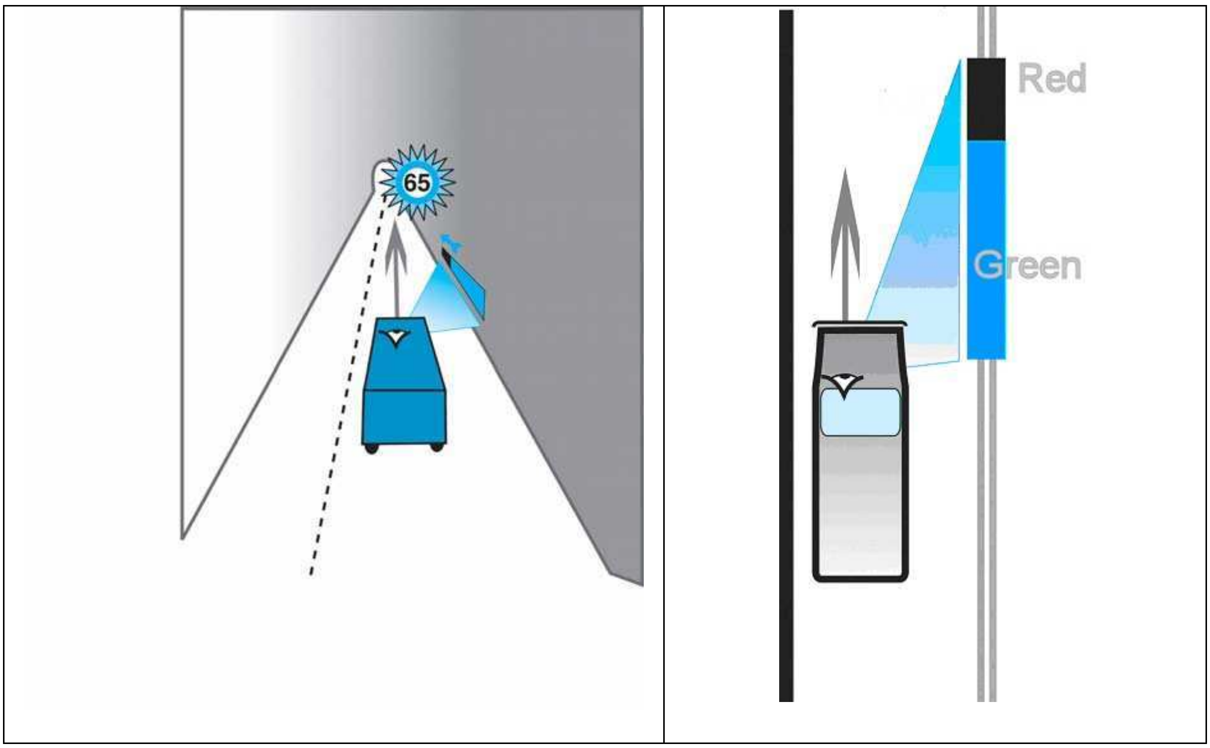
Some systems can recognise drivers based on finger print recognition or face shape recognition. For each driver, several parameters are registered, such as maximum speeds. In practice, it can be used for young drivers and, in the longer term, it could also be used for repeat offenders (similarly to the use of alcohol interlock systems for repeat drink-driving offenders).

Applications for speed management in tunnels

In tunnels, two informative systems are currently being investigated:

- The "ferret", a beam located on a roof of the tunnel or on a side wall, that road users can follow in order to comply with speed limits and maintain appropriate distances between vehicles (see figure 10.8).

Figure 10.8. **Applications of ferret in tunnels to guide the drivers on the appropriate speed**



Source: Durand Raucher

- The "illuminated drag", which emanates (flows) from each vehicle (by the ignition of diodes when a vehicle passes by, at a length which takes into account the vehicle speed and the required safety interval) and which indicates the minimum safety interval to the drivers following behind.

Experiments on these different systems are expected to take place in the future.

French SARI Project - Automatic road condition monitoring

This research project sponsored by the French Government through the PREDIT 3[7] programme aims to increase understanding of how roads influence accidents and investigate how future co-operation between the road and vehicles might use this information to provide drivers and road

7. PREDIT is the acronym for Programme de Recherche et D'Innovation dans les Transports terrestres (*programme of research, experimentation and innovation in land transport)*. PREDIT 3 was the third such programme and covered the period 2002-06.

managers with real-time information, including advance warning of potentially hazardous driving conditions or obstacles requiring lower speeds. The expected outcome is to bring about significant reduction in the number of accidents in which drivers leave the road or lose control of their vehicles on rural roads in France.

The SARI programme contains research of a varied nature. The first stage is improving knowledge about the way difficulties on the road affect the behaviour of drivers and vehicles. Other stages will develop techniques to identify and characterise these difficulties (test vehicles) and to develop prototype information systems, and carry out full-scale trials in order to evaluate the effectiveness of implemented systems, in particular how they affect driver behaviour. The programme could also comprise personalised information, taking into account the characteristics of the driver (*e.g.* young drivers). An ergonomic study will also be undertaken to decide on the types of information (factual or interpreted), the type of media (VMS, integrated with the vehicle's navigation system, etc.) and the forms of the message (visual, text, audio) that will have the most impact, depending on the nature of the information (strength, frequency, importance).

In summary, the project will provide advice for speed choice, based on the local characteristics of the road, the weather conditions, the type of driver, the type of vehicle, etc.

10.3. Policy considerations

Intelligent Speed Adaptation (ISA) is an important application of new technologies that can help provide information and assistance to drivers to help them comply with speed limits and to drive at appropriate speeds. By guiding or moderating speeds, ISA systems can potentially make a major contribution to reducing fatalities and injuries by reducing vehicle speeds. Widespread deployment would provide a potentially powerful means to reduce road accidents.

From a technical viewpoint, widespread implementation of *informative ISA* would be possible in the near future. In order to enable large scale ISA deployment, policy support and a range of coordinated supporting actions are required (*e.g.* development of electronic speed limit databases).

Some countries are well advanced in trials of ISA systems. In Europe, a number of national administrations and equipment manufacturers, with the support of the EC, are making progress on the *SpeedAlert* project, which will help assure that a range of required co-ordinated actions are undertaken.

This OECD/ECMT *Speed Management* project supports the progressive introduction of *driver speed assistance* ISA systems, with these promoted as able to provide voluntary support for less speeding and increased traffic safety. Under *Informative* ISA, drivers remain fully responsible for their driving. Most field trials have focused on the use of ISA in urban areas, and it is also clear that user acceptance is much higher in urban (low speed) areas with dense traffic than in, for example, a motorway environment.

If approved by national governments, there are a number of technical issues that will need to be addressed, including:

- National and regional authorities will have to establish speed limit databases, and administrative structures and routines for maintaining the quality of information. Such databases need continuous updating to cover changes and temporary speed regulations.

- International and national institutions will need to establish standards for speed limit data exchange format, and also standards for a generic interface for communication of speed limit information to vehicles.

- International co-operation will be needed not only for standardization issues but also on the definition and, potentially, procurement of government (and possibly other) inputs required for a first generation ISA for broad deployment in existing national vehicle fleets.

Once the issues are resolved, governments will be well placed to use their fleet buying power to purchase ISA-equipped vehicles for their own use. Sustained ISA purchasing policies may provide a sufficient incentive for aftermarket and original equipment suppliers to develop systems that could be offered to private and business users for retrofit or as new vehicle equipment.

It is suggested that each country takes action to ensure that:

- New cars are equipped with *voluntary informative or supportive ISA* to assist drivers to adhere to speed limits (static and eventually variable and dynamic). This will require international co-operation to establish standards, procedures and speed limit databases.

- Reflecting the potential substantial safety benefits, *mandatory supportive (intervening)* ISA applications are given further consideration for the longer term, recognising and taking into account the changes in philosophies and liabilities that could be involved[8].

Supportive ISA is legally more complicated if mandated for use. The key issue is liability in the case of system malfunction or because of erroneous data, and this needs to be resolved before implementation of *supportive ISA* systems could be mandated for compulsory use.

In the longer term, the vision could be of an intelligent highway where communication between individual vehicles and roadside infrastructure assists or even actively controls vehicles from the roadside. It is expected that this vision may be of most benefit on strategic road networks.

8. For legal, liability and operational reasons, one country (Germany) has advised that it does not support the development and implementation of supportive ISA, whether voluntary or mandatory.

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PART III: EVALUATION FRAMEWORK AND TECHNOLOGY TRANSFER

Part II of this report presented the various individual measures that can be implemented to better manage speed.

This Part III – composed of Chapters 11 to 13 – first looks at how these different measures can be combined into a speed management policy package and the role of a speed management policy framework in creating safe mobility systems. It also highlights the important roles of the various actors for a successful speed management policy.

While the core of the report was mainly written for the attention of OECD/ECMT countries, Chapter 12 highlights the specific needs of the less developed countries and underlines areas where the measures described in this report could be best adapted to those countries.

Finally, Chapter 13 presents a summary of the recommendations of this report.

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CHAPTER 11

INTEGRATED SPEED MANAGEMENT AND MAIN ACTORS

The preceding chapters have reviewed individual measures to manage speed and its effects. This chapter revisits the objectives of speed management, identifies how the different measures considered in earlier chapters can be combined into a speed management policy package and reviews the role of a speed management policy framework in creating safe transport / mobility systems. The chapter concludes by describing the roles of the various actors involved and the actions they can take to achieve the desired speed management outcomes.

11.1. Objectives of speed management

Speed management has a variety of objectives, such as improving:

- Road safety, by reducing fatalities and injuries on the roads.
- The environment, by reducing adverse impacts, such as noise and pollution.
- Quality of life, especially for people living in urban areas, including the most vulnerable persons.

In developing a speed management policy, the full range of objectives defined by the government and other relevant considerations, such as the levels of adverse impacts, need to be taken into account. Of course, the nature of the impacts is different in each case. Speed management policy nevertheless provides a framework within which authorities can seek to strike the right balance between various objectives, and in particular safety, mobility, environment and quality of life.

When considering the need to reduce road safety impacts, public authorities have to take fully into account their responsibility for protecting human life and reducing avoidable serious injuries on the roads. This is a fundamental responsibility that is distinctly different from other objectives such as government interest in improved economic circumstances for their citizens. To reduce road trauma, *i.e.* fatalities and injuries, authorities need to take action to reduce vehicle speeds on the roads and their adverse impacts on road safety and thereby help achieve the reduced road safety targets governments have set.

Of course, adequate consideration will also need to be given to other impacts and issues *e.g.* those related to social and economic development, protection of the environment, liveability of the cities and so forth. The policy deliberations should take into consideration international targets, such as the Kyoto protocol on CO_2 emissions (where applicable). Some of these impacts (*e.g.* quality of life) are not easy to gauge, which makes any assessment of alternative measures in a speed management policy (including monetary) a challenging and political exercise.

Local circumstances differ, so even if the speed management policies in different countries contain similar broad strategies, the measures implemented may vary from one country to another.

11.2. Speed management within a safe mobility system

The vast majority of countries in the world apply road safety measures, in one form or another, to manage the speed of motorised traffic. These may range from general speed limits, to targeted police enforcement, publicity, infrastructure measures, and the use of new technologies in vehicles or along roads.

It is preferable for a speed management policy to be based on a broader road safety philosophy, which in turn supports the road safety strategy and road safety action plan. Road safety philosophies, strategies and action plans mostly have decreasing timescales, and increasing levels of detail and practicality. As outlined earlier, road safety philosophies generally include a view on what the ultimate, ideal situation would be. The aims are normally very ambitious and their achievement only possible in the long term (if at all).

One common element of many current road safety philosophies is that most road accidents and road casualties are phenomena that can be prevented. In other words, they are not seen as unavoidable events or an inescapable consequence of people's demand for mobility. Taking this position means that a society sets itself a moral responsibility and government and other stakeholders a duty to stimulate, motivate and facilitate road safety measures aimed at giving effect to this philosophy. Examples of such philosophies are *Vision Zero* in Sweden (Swedish Road Administration, 2000) and *Sustainable Safety* in the Netherlands (Koornstra, 1991; see also Van Schagen and Janssen, 2001; Wegman and Aarts, 2006) (see Annex A), but other countries, too, have developed similar philosophies, even if these have not been given as widely recognised names.

If most accidents are considered preventable, a good understanding is needed of the nature of the road safety problem and, consequently, of the means to reduce it. From there, it is a logical step to develop a comprehensive road safety strategy, which may be part of a wider transportation or mobility plan.

A road safety strategy has a shorter timescale than a road safety vision, and typically covers a period of five to ten years. The key areas for action can be identified and the broad strategies described, based on an in-depth analysis of the road safety situation and identification of the major areas of concern. These key areas may be defined by high risk behaviour (*e.g.* excessive speed, drink driving), by high risk road user groups (*e.g.* young drivers, the elderly, children), or by frequent accident types (*e.g.* single vehicle accidents on rural roads). A comprehensive road safety strategy should cover all aspects of the road safety problem.

Finally, an action plan should describe the actual measures to be taken to tackle the identified problem areas. Generally, it would contain a description of the road safety measures, as well as the financial and organisational means to support their implementation. Speed management measures would be a logical part of such an action plan.

11.3. Assessment of collective benefits

To be acceptable to the public, speed management policies and measures need to focus on the benefits to society of ensuring vehicles travel at safer speeds, taking into account the priorities (*e.g.* young drivers and vulnerable road users). They also need to strike a balance between the other policy objectives (*e.g.* environmental, sustainable mobility and quality of life) and target groups (*e.g.* people who live near busy roads with high speed traffic). Acceptability will be enhanced if the public is well informed. Vehicle owners for example need to understand the potential for reduced operating costs of their vehicles that a speed management policy can provide.

Settling and gaining public acceptance for a speed management policy is not an easy task, because individual and collective benefits have to be reconciled with individual and social responsibilities. Most of the time, driving a little faster than the posted speed limit does not lead to disastrous consequences. At an individual level, the risk of an accident is relatively small. Similarly, the impact of one driver on the environment is very small and can seem negligible to the driver. As well, speeding often allows (small) gains in travel time. Therefore, from an individual’s point of view, it is likely that increasing speed will seem to offer more benefits than disadvantages.

From a societal point of view, though, things are seen differently: the accident risks (and the accident costs) are far from negligible, as are the aggregate impacts on the environment of a high proportion of vehicles speeding, even if the majority speed by less than 10 km/h over the speed limit. What is considered individually beneficial and acceptable by the majority of people individually is not necessarily desirable from society’s viewpoint, mainly because of the difference between private and social costs. For example, road users will be aware of individual benefits of speed (time savings) but not necessarily fully aware of the associated losses for society (road safety, air quality, etc.) – losses which are mostly borne by others.

Decisions concerning speed management should be based on explicitly formulated principles and after careful consideration of all possible impacts in order to aid transparency. The reasoning behind decisions, and the weight given to different impacts, should be clearly stated (Kallberg and Toivanen 1998). Table 11.1 from the MASTER[1] project shows impacts on different groups of people – as well as indicative impacts on animals and vegetation – entailed by a lowering of average speeds.

Table 11.1. **Distribution of impacts based on the MASTER framework**

Groups affected by lowering the average speed of light vehicles from 92 km/h to 82 km/h:

	Vehicle costs	Travel time	Accidents	Pollution	Total
Cars users	+ slight reduction	– increase	+++ reduction	+ diminished exposure to air pollutants and noise	– +++++
Bus passengers	Not applicable	– The number of too slowly driving light vehicles might increase	++ reduction	+ diminished exposure to air pollutants and noise	– +++
Pedestrians and cyclists	No impact	+ crossing the roads becomes easier	++ increased safety	+ diminished exposure to air pollutants and noise	++++
Transport operators	+slight decrease	– increase in travel time and related costs	++ savings in accident related costs	+ diminished exposure to air pollutants and noise	– ++++
Nearby residents	Not applicable	– increase for car users	+ reduction	++ diminished exposure to air pollutants and noise	– +++
People with low income	+ slight decrease for car users	– increase for car users	++ reduction	+ diminished exposure to air pollutants and noise	– ++++
People with high income	+ slight decrease	– increase	++ reduction	+ diminished exposure to air pollutants and noise	– ++++
Men	+ slight decrease for car users	– increase	++ reduction	+ diminished exposure to air pollutants and noise	– ++++
Women	+ slight decrease for car users	– increase for cars users	++ reduction	+ diminished exposure to air pollutants and noise	– ++++
Plants	Not applicable	Not applicable	Not applicable	+ diminished exposure to air pollutants and noise	+
Animals	Not applicable	Not applicable	++ reduction	+ diminished exposure to air pollutants and noise	+++

This table shows that lowering the average speed of light vehicles can have a wide range of impacts on different groups of people and also on plants and animals. Overall, lowering speeds is likely to have a positive impact on all these groups. Such multi-criteria analyses are very interesting and should of course be refined and tailored for each speed management project and context.

1 MASTER : EC project on Managing Speeds of Traffic on European Roads

11.4. Components of a speed management package

Seeking synergies

A speed management policy logically consists of a number of components, and obviously seeks the best possible synergies between the various individual measures. Isolated measures may have an impact, but if implemented in isolation will most likely not be the most effective way to achieve a durable reduction in speed required. While all measures should be complementary, some combinations will be more effective. As an example, there is a strong link between the road infrastructure and signing and marking, and of course between legislation and enforcement. Looking to the future, informative ISA and enforcement would be a good combination. When driving in a vehicle fitted with informative ISA, the driver knows at all times the prevailing speed limit. In a road safety environment characterised by a strong enforcement policy, use of informative ISA technology could become a very effective tool in helping drivers respect the speed limits at all times and avoid sanctions. Importantly, the successful use of ISA technologies depends on the local speed limits being adequately set up.

As outlined earlier, in an ideal world, and when starting from scratch, the logical process for policy and operational development and implementation would be as follows:

- Identify the function of the road.
- Assess possible impacts on safety, the environment and the economy associated with the road and its traffic.
- Define appropriate speed.
- Design the road in order to match the road design with the appropriate speed.
- Define speed limits according to appropriate speed.
- Add signing and marking.
- Carry out information campaigns, where necessary.
- If this does not lead to appropriate speed outcomes, add enforcement.

In the real world, however, most roads are already built. So, it will hardly ever be possible to begin from scratch and pass systematically through each of these steps. That does not mean that in an existing network a systematic, comprehensive approach to speed management is not possible. For an existing road network, a speed management package would desirably be developed over time, progressively building on the outcomes of the following successive steps:

1. Determine the function of the road, including the type of road users allowed

In practice, for some countries this might mean that they need to (re)categorise the road network in terms of road functions, *e.g.* access function, distributor function and flow function (see Chapter 4). Generally, the function of the road also determines which types of road users are allowed to make use of the same space.

2. Determine the appropriate speed, both for road stretches and for intersections

The appropriate speed depends on the road function, the traffic composition, the type of potential conflicts, design characteristics and would not compromise on safety. For example, based on the ideas of Vision Zero (Tingvall and Haworth, 1999), the Dutch Sustainable Safety philosophy (Wegman and Aarts, 2006) recommends the safe speeds for different road types as described in Table 11.2:

Table 11.2. **The Sustainable Safety proposal for safe speeds, given possible conflicts between road users**

Road types combined with allowed road users	Safe speed
Roads with possible conflicts between cars and unprotected road users.	30 km/h
Intersections with possible transverse conflicts between cars	50 km/h
Roads with possible frontal conflicts between cars	70 km/h
Roads with no possible frontal or transverse conflicts between road users	≥ 100 km/h

Source: Wegman and Aarts, 2006

3. Set a speed limit that reflects the appropriate speed and that is credible

Speed limits are the basis for helping people to drive at the desired, appropriate speed. For achieving that goal, it is important that the speed limits are credible, *i.e.* that they are considered logical in the light of the characteristics of the road and the road environment. If this is not the case the situation (speed limit in relation to road and roadside characteristics) needs to be reconsidered and either one or the other changed. Variable and dynamic speed limits that take account of actual circumstances (see Chapter 5) will enhance the credibility of speed limits.

4. Apply road engineering measures where low speeds are crucial for safety

At particular locations low speeds may be crucial for safety (perceived or actual). Examples are near schools or homes for the elderly. At these locations, physical speed reducing measures such as speed humps can force drivers to maintain a safe speed. As well, at intersections and at entrances of built-up areas, measures such as roundabouts are a good means of reducing speeds (see Chapter 4). Road engineering measures can also be applied in larger urban areas to promote low-speed zones (*e.g.* Zone 30).

5. Make sure people actually know the speed limit in force

Good compliance with speed limits also requires that road users always and everywhere know what speed limit is in force. Clear information about this must, therefore, always be provided. This can be done in the usual way by consistent signing and marking on, or alongside, the road (see Chapter 6). A more advanced, but already operational possibility is to display the limit inside the vehicle, *e.g.* linked to a navigation system (see Chapter 10).

6. Inform and educate the drivers about speed and speed management

All of the former steps must be accompanied by information to drivers on the effects of speed and speeding, clear advice on the basis of the speed limit system and supporting reasons, what additional measures need to be taken and why, and preferably also on the (positive) outcomes to be expected from these measures (see Chapter 8).

7. Police enforcement to control the intentional speeder

If each of the former steps has been applied, it can be assumed that unintentional speed violations are an exception. Most drivers who still exceed the speed limit therefore do so intentionally. Police enforcement will remain necessary to control and sanction this residual group of speeding drivers (see Chapter 9).

8. Take account of developing vehicle technologies

Speed management also needs to take into consideration progressive implementation of new vehicle technologies as they become available (see Chapters 7 and 10) and more widely accepted in future. As the normal life expectancy of vehicles is around 10 to 15 years, however, it will take time for such new technologies to be introduced widely into vehicle fleets.

In undertaking these eight steps, careful consideration also needs to be given to the potential negative impacts of a speed management policy. As an example, too much enforcement on roads where the limit in force is not very credible or without proper information about the need for such a measure, might have a negative impact on the overall public acceptability of road safety measures, and thus have negative consequences for the overall road safety policies. A sensible balance of the various measures available is required.

Overall, it is clear that this progressive step-wise approach to the development of a comprehensive speed management policy package requires good co-operation between different actors, including road authorities, regulators, enforcers, educators/instructors, and car manufacturers (see also section 11.5).

Different types of road environments

The problems with road accidents in rural and urban environments are different and require different approaches. While a number of black spots do exist on rural roads, most accidents in rural environments are spread across the whole rural road network and, due to high speeds, they tend to be very serious. In the urban environment, the accidents are more concentrated and more of the victims are pedestrians or two-wheelers.

In rural areas, there are few means to influence speed and road safety directly. Infrastructure measures (such as median barriers) are very effective in reducing serious accidents, fatalities and injuries. However, they require a long-term programme and are relatively expensive for large scale implementation at a network level. Enforcement is also important but the costs of an effective enforcement strategy (*e.g.* with mobile cameras) are high, meaning it is unlikely to produce positive cost-benefit or cost-effectiveness ratios in many rural areas. New technologies and, in particular, intelligent speed adaptation, seem to offer promising ways of effectively moderating speed in rural areas. Section control on more heavily trafficked rural roads may also be in prospect once suitable technologies have been developed for motorway applications.

Although motorways have a reputation for being the safest type of roads, speed management actions should also target this category, as they can showcase possible actions in the field of speed and traffic management. For most road users, speed enforcement on motorways provides highly visible evidence reinforcing their subjective assessments of the risks of being caught speeding. A consistent speed management policy on motorways generally has a strong impact on road users.

The options available to manage speed in urban areas are much more diverse. A wide range of measures can be tailored to the specific needs and environment of each city.

Finally, speed management is not only concerned with implementing local measures for specific networks or types of road. Consideration should also be given to national approaches to speed management, including policy coordination on matters such as new technologies and national approaches to education, training and information which will play a central role.

Countries with different levels of road safety performance

Countries in the OECD/ECMT regions are disparate regarding their levels of road safety performance. One of the reasons for this is that, while some countries have been active in implementing a variety of speed management measures over a long period of time, others are at a relatively early stage in their road safety work. Given this great variety in starting points, the strategies for road safety management will vary considerably throughout the OECD/ECMT regions (and the rest of the world).

Countries with good safety performance have had greatest success in addressing the road safety problems in urban areas, often by applying a variety of speed limiting measures (*e.g.* lower speed limits), physical infrastructure measures (*e.g*. speed humps) and more effective enforcement. However, much still remains to be done, and adopting and tailoring best practices experienced by other countries can help. A key challenge remaining for the best performing countries is to address the speed issues in rural areas.

Road accidents on rural roads are in fact a challenge which has to be addressed in most countries, including those with both higher and lower levels of road safety performance.

Nevertheless, the experience indicates that countries with relatively poor safety performance could be expected to have greatest success in the short term by giving priority to addressing the road safety problems in their urban areas.

Chapter 12 addresses briefly the issue of speed management and knowledge transfer to developing countries.

11.5. Roles of the different actors

Coordination of speed management actions across the various stakeholders is a prerequisite for success. At the local and national levels, there are large groups of people and organisations that have responsibility for the different measures in a speed management action plan. While each of these groups, and others, have roles to play, it is essential that they cooperate in the development of a speed management policy and the implementation of a speed management plan. Table 11.3 describes the desirable actions expected from actors involved in a speed management policy.

Table 11.3. **Expected actions from the different actors involved in speed management**

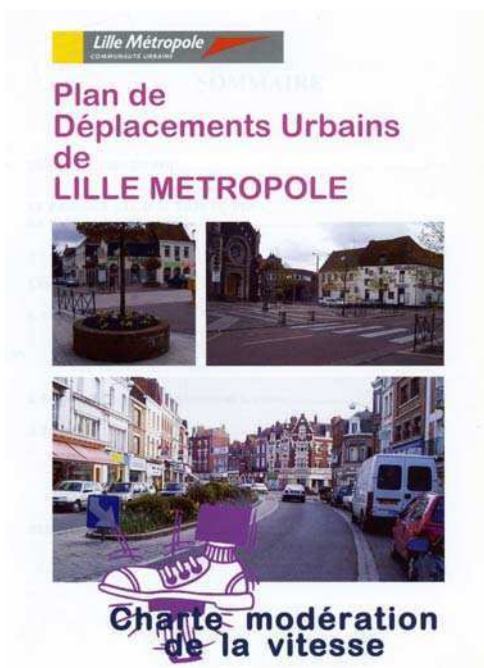
National and regional authorities	• Decision makers at various levels have an important role in speed management. They should be as fully informed as is practicable about its effects, such as the difference between private and social costs, the impact on public acceptability of different speed management strategies and tools, and the fact that popularity is not necessarily a good criterion for sustainable speed management (Kallberg *et al* 1998). • Transport ministers should work in close co-operation with environment and health ministers, since reducing speed has clear benefits for other sectors as well. • A common vision for a lower-impact and more sustainable transport system needs to be developed by national and regional authorities responsible for transport, energy, transport planning, environment, health, justice, education and police, together with, for example, municipal governments, and other departments responsible for land use planning. • National authorities are responsible for setting general speed limits (at national level). In this respect, consideration should be given to a possible harmonisation of general speed limits between countries/regions. • As harmonisation of measures reinforces their credibility with the public, national governments should look at harmonising speed control for similar road types, both at country/state level and between countries/states. • Authorities should develop multi–lateral agreements for controlling the speed of foreign drivers and for the development of long-distance (international) section control for coaches and trucks, and - in a second stage - for cars. • Adopt a pro-active role in better explaining the dangers of speeding and the reasons for speed management measures to the general public.
Local authorities	• Define the function of each road and review existing speed limits and ensure that they are consistent, credible and therefore more easily enforceable. • Develop low-speed zones (Zone 30) integrated in the local transport plan. • Ensure there is policy support for speed management measures. As an example, a charter on speed-related issues could be a good way to involve policy makers at local level (see figure11.1).
Police authorities/ Interior Ministries	• Ensure that road safety enforcement is closely aligned with speed management policies. • Enforce speed limits in the most effective ways possible, given available resources.
Vehicle industry	• Continue efforts on active and passive vehicle safety. • Propose and promote systems that assist the driver in respecting speed limits. • Avoid promoting or glamorising speed in advertising campaigns.
Technology industry	• Research and develop systems that are easy to understand and use (particularly by the elderly) and dot not produce adverse consequences.
Insurance	• Become more involved in road safety and take a business approach to investments in the implementation of speed-related policies and operational improvements. . • Pursue an incentives-based approach. For instance, promote ISA, EDR, or other speed and safety related systems, by reducing premiums for cars equipped with these systems.
Media	• Adopt a pedagogical role to better explain to the public the danger of speed and the benefits of traffic calming as well as the reasons for speed management measures. • Avoid, directly or indirectly, advocating high speed driving.
Inter-governmental agencies	• Inter-government agencies (*e.g.* OECD, ECMT, EU…) can play a leading role via conferences, symposia and committees to foster the development and exchange of information and views. These could identify relevant trends and interactions among governments, the public and various industries, including energy, automotive, infrastructure, transport and transport-dependent industries. • Establish an international body or cooperation programme to manage and assure international enforcement of foreign drivers.
Driving instructors	• Driving instructors should be well educated on the issues of speed and its effect and pass the message to the learner drivers.
Other actors	• Researchers, medical doctors, teachers, professors, parents and family in general also have an important role to play for speed moderation.
Road users	• Finally, it should not be forgotten that the road user (whether driver, pedestrian, cyclist, etc.) is at the heart of the whole system. The success of speed management depends on user acceptance – whether this acceptance is voluntary or not.

In a number of countries, a "new generation" of road safety policies is developing, whereby there is a greater involvement of the civil society and greater acceptance of responsibility by all stakeholders for ensuring improved road safety outcomes. A large part of the population is, generally, becoming more in favour of road safety and is calling for safer mobility. There is growing pressure, within some populations, for more sustainable vehicles which are both low polluting and less aggressive, especially towards vulnerable road users. In France, for example, an association for road safety has developed the concept of the *Citizen Car,* and ranked all new vehicles based on their road safety characteristics (for both car occupants and vulnerable road users) and their environmental impact (Ligue contre la violence routière, 2005).

Greater involvement of insurance companies could also lead to significant changes, in particular for young drivers. There have been recent initiatives from insurance companies offering lower premiums for vehicles equipped with the latest safety equipment (*e.g.* ABS, ESP), and for installing EDRs to effectively monitor speeding and distance travelled.

In some countries, coalitions have developed between different actors (local authorities, population, industry, etc.) to promote safety and safer speeds. In Lille (France), for example, the various actors have agreed on a charter for speed moderation, which has been fully integrated in the urban development plan (see figure 11.1).

Figure 11.1. **Charter for speed moderation in the city of Lille (France)**



(Plan de déplacements urbains de Lille Métropole = Urban travel plan for the agglomeration of Lille
Charte Modération de la Vitesse = Charter for speed moderation)

11.6. Monitoring

When implementing speed management measures as part of a wider road safety effort, it is essential to monitor the development of speeds on the roads as well as the accident situation. Speed (as well as accidents and traffic volume) should be regularly measured on roads which have received specific treatment, to evaluate the effectiveness of individual measures.

Speed measurements should also be made across the overall network, in order to evaluate the global effectiveness of a speed management package.

These measures are useful for the authorities to assess the success of a speed management policy. Further evaluation, for example on air quality and noise, could also be carried out (some simulation tools already exist in this field).

These monitoring programmes are important, in order to gain knowledge and experience and to communicate the results to the politicians and the general public. Whenever relevant and possible, cost effectiveness should also be evaluated.

11.7. Policy considerations

Speed management is a valuable tool by which the authorities can improve road safety and find the right balance with the other different factors that need to be taken into account, such as mobility, environment and quality of life. A speed management policy will therefore have a variety of objectives, including improving road safety, the environment and quality of life and minimizing adverse impacts (*e.g.* on businesses). Preferably, a speed management policy will be based on a broader road safety philosophy, which in turn supports the road safety strategy and road safety action plan adopted. The measures taken will also need to be consistent with achieving the targets that have been set for improved road safety outcomes.

Speed management has the potential to contribute to the twin goals of improved safety and a better environment and this should be widely made known and promoted, to gather support for action to address the adverse impacts of speeding and support for the measures proposed.

There are big differences in road safety performance between countries. It is evident, therefore, that the strategies for road safety and speed management will vary considerably throughout the OECD/ECMT regions (and the world). It is suggested that those countries without a long history of speed management begin by developing their strategies in urban areas, where the greatest safety gains, especially to vulnerable road users, can be obtained quickly. In developing countries, great efforts must also be made to raise the general public's awareness of the dangers of speeding.

Decision makers at various levels have an important role when it comes to speed management. They should be well-informed of the effects of different measures, and they should be aware of the difference between private and social costs and the likely level of public support for and acceptance of the different speed management tools. In particular, they should be aware that announcements of speed management measures will not necessarily be popular in the short term. However, speed management efforts are likely to be more widely supported as the overall benefits become evident and improved results are achieved. In other words, short term reactions are not necessarily a good criterion for choice of sustainable speed management policies.

Co-ordination of actions at local and national levels is highly recommended to ensure successful implementation of speed management measures. There should be a focus on competence on speed management issues at national, regional and local levels.

While highway engineers, educators and trainers, the police, vehicle engineers, and others, have important individual roles to play, it is essential that they are fully engaged and cooperate in the development of a speed management policy and the implementation of a speed management plan.

When implementing speed management measures as part of a wider road safety effort, it is also essential to monitor actual speeds on the roads, as well as the accident situation and other environmental and behavioural consequences. This is important, both in order to gain knowledge and experience, and to communicate the results to the politicians and the general public. All countries are encouraged to monitor speeds on their road network regularly, as this is a major performance indicator with respect to both road safety and environmental objectives.

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CHAPTER 12.

KNOWLEDGE TRANSFER TO DEVELOPING COUNTRIES

This chapter focuses on the specific road safety situation in less developed and developing countries and highlights the speeding related issues in these countries. It focuses on areas where measures described in the previous chapters of this report can potentially be adapted to the conditions of the less developed countries.

12.1. Road safety situation in less developed and developing countries

The assessments and findings outlined in this report relate principally to OECD/ECMT member countries.

At a global level, the WHO/World Bank's "World Report on Traffic Injury Prevention" (WHO, 2004) indicates that around 1.2 million persons are killed each year and up to 50 million injured[1]. In 2004, road traffic was the ninth leading cause of disease or injury. Unless strong actions are taken, the situation will get much worse, particularly in developing countries. If current trends continue, the WHO expects road traffic will be the 3rd leading cause of disabled adjusted life years lost (an index that combines years of life lost as well as years free from disabilities) from disease or injury in 2020.

In most developing countries around the world, there is little road safety data collection and analysis and, therefore, it is not possible to be specific about the contribution that speeding makes to their overall road safety problem.

However, given the universality of speeding as a key cause of fatalities and injuries and therefore as a key road safety factor, all countries need to take concerted and resolute actions to address and reduce the extent of excessive speed – *i.e.* speeds over the legal speed limits – as such action will achieve early and durable benefits in reduced road traffic accidents, fatalities and serious injuries.

Many of the specific speed-management measures outlined in this report may be applicable in less developed and developing countries.

The adoption of a safe transport system approach and the development of policy, legislation and restrictions on speeding – in conjunction with action on drink-driving and requirements for seat belt wearing – are likely to have wide applicability.

If countries can support such measures with as much enforcement as resources allow, they will not only be addressing their own road safety problems but will also be helping prevent the unacceptable global outlook identified by the WHO from being realised.

The following sections provide some insights based on the experience of Working Group members with speed-related issues in developing countries.

12.2. Speeding-related issues in developing countries

While there is generally limited or no detailed data on accident causation in developing countries, it can be assumed that speeding is a major problem and that a significant number of lives could be saved by selectively introducing appropriate speed management principles.

The specific characteristics of developing countries include the following factors:

Fast growth in motorisation. The level of motorisation in most developing countries is relatively low; however it is growing very fast in some countries. In India, for example, the number of motorised vehicles was multiplied by more than 10 between 1985 and 2002 (Ministry of Road Transport and Highways, 1999, 2000, 2003), with a very high proportion of motorised 2-wheelers. As a

1. As an example, in China, where the fleet counts around 27 million cars (equivalent to the fleet of Spain), WHO estimates that there are every year around 250 000 road fatalities, i.e. 50 times more fatalities than in Spain.

consequence, where this happens, the population has to adapt very quickly to completely new traffic conditions and situations.

Diversity of the traffic composition. The traffic composition in most developing countries is very diverse and heterogeneous. On the same roads, there will be trucks and vans, cars, buses and coaches, motorcyclists, scooters, cyclists, horses and possibly carts, other animals and many pedestrians, creating a wide range of potential conflicts. Of course, such potential conflicts are exacerbated at night-time, with many vehicles, pedestrians and cyclists probably not visible. As well, many vehicles may run with defective lights or use full headlights.

In terms of motorised vehicles, one of the greatest differences from industrialised countries is likely to be the very high proportions of motorcycles and other motorised two-wheelers in developing countries.

Bad road conditions. A large part of the network is unpaved. The roads are not maintained properly. There is a lack of signing and marking.

Function of the roads. The road is often considered as a social place where many children play.

Overloaded vehicles. Vehicles are often overloaded. In particular, vehicles often transport more people than their normal maximum safe capacity.

Figure 12.1. **Vehicles are often overloaded**

Source: Nouvier

12.3. Tailoring speed management measures for the needs of developing countries

Many of the measures described in this report can also apply to these countries. Attention must however be given to carefully tailoring them to the specific needs and to the culture of each country. The following paragraphs highlight areas where these measures could potentially be adapted.

Education and training

Usually, in developing countries, there is a very low level of awareness of the dangers of speed. In addition road accidents are often perceived as inevitable and their outcome a fate which could not have been avoided. It is therefore important to better educate the whole population (not only the drivers) about road safety, including on the fact that accidents and their effects are often avoidable. Education and training together are a real necessity and must be tailored to the level of education of the people and the culture of each country. As for all countries, education and information activities should start at schools and be a continuous and sustained action.

Driver education is also very important. Best practices from developed countries, including the proper education and training of driving instructors, could be relatively easily transferred. Of course, driver education programmes should take into account the fact that, given the general level of education of the people may be relatively low, a significant proportion of drivers may not be able to read properly. Safety campaigns are also needed and should be developed. In this respect, it is important that the population recognise itself in the posters or advertising spots used in the campaigns; one can not simply use information campaigns and images developed for industrialised countries. For some countries, for example, an information spot featuring a white female driver would probably have little impact. To be effective, the campaigns must be related to the local environment.

It is also particularly important to give specific attention to proper road safety education and training of professional drivers who represent a high proportion of the driver population.

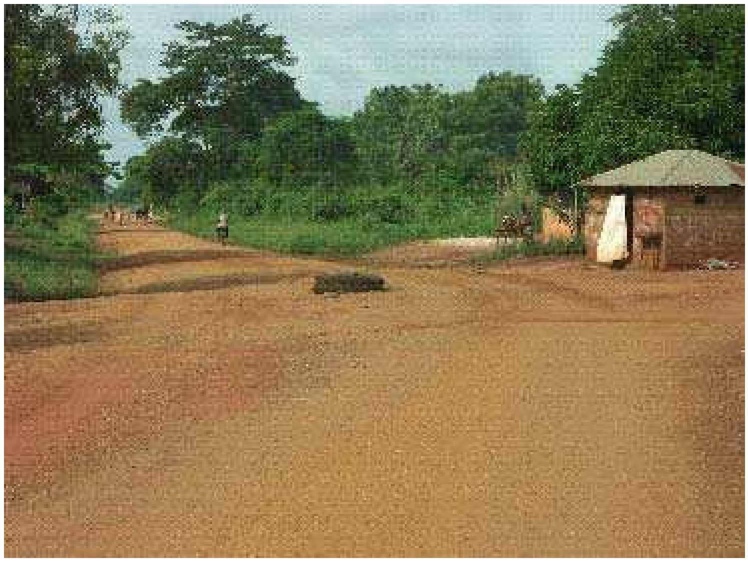
Infrastructure and signing

In most developing countries, the road conditions are very poor. A large part of the road networks are comprised of unpaved roads and the road networks themselves are not yet well developed. There is likely to be a relatively poor road surface in many locations with a lot of potholes and other obstacles. We are likely to be far from a Vision Zero concept, with its high quality infrastructure and well maintained and separated carriageways. Moderate speed is therefore an absolute necessity to be able to avoid obstacles; otherwise, the risk of a frontal accident or of running off the road is very high.

Unpaved roads are progressively being paved in many countries but this can have serious consequences for pedestrians: vehicles will be travelling faster, with all the increased risks associated with higher speed; pedestrians, accustomed to crossing unpaved roads used by relatively slow moving vehicles, will face quite different traffic conditions and high vehicle speeds. Without the necessary experience to deal with these conditions, the pedestrians could be greatly at risk of serious injury from the fast moving traffic on the roads.

As a result, the transformation from unpaved roads – in situations like the one shown in Figure 12.2 – to paved ones may cause particular difficulties, as neither drivers nor the local population will be used to fast traffic. The extended transition periods involved in upgrading roads of this type are therefore likely to be particularly dangerous for pedestrians, but also for drivers.

Figure 12.2. **What will happen when this becomes a paved road?**



Source: Nouvier

Many things can however be done. First, where the road network is not yet well developed, there will be significant opportunities to apply sound engineering practices from the outset of the road design. In this respect, the following basic rules and guidelines are to be recommended:

- Avoid large roads for crossing villages; rather narrow the roads at the entrance to the village.
- Avoid new developments and construction of houses and shops along new roads. Avoid building a major road along a shopping or residential area.
- Apply speed moderation devices - such as a roundabout - at the entrance of a village.
- Apply speed humps in cities and villages. They are a very cost–effective way to reduce speed.
- Ensure consistent signing.
- Construct parallel pedestrian paths, to avoid pedestrians walking along the same surfaces that are used by motorised vehicles.
- Prefer roundabouts to intersections. Roundabouts are a little more expensive, but they are effective in reducing accident severity.

It should also be noted that a large number of severe accidents occur in big cities, where vulnerable road users are particularly at risk (Muhlrad, 2002). Efforts are needed especially to make the major arterial roads safer by developing dedicated space for vulnerable road users since most pedestrian activities take place in the vicinity of these roads.

Vehicles

Usually vehicle fleets are quite old, and include many very old vehicles. It would be inappropriate to expect to find technologies such as electronic stability control (ESC or ESP) and Intelligent Speed Adaptation (ISA). Even the standard technologies which could be expected to be available on board the vehicle (speedometers, for example) may be missing. As well, most of the normal safety devices in modern cars (such as seatbelts or air bags) may be missing or not functioning/not used. The consequences of old vehicles without the normal safety devices are likely to be more – and more severe – accidents.

The first recommendation would be to make vehicle inspections compulsory. These inspections should focus on key road safety components, such as the braking and steering functions, lights, tyres, etc. It is recommended to repair when possible the speedometer, as this constitutes the main and usually the sole indicator for the car driver to assess his/her speed. It is also important the vehicle fleet evolves with the road network. As an example, the fleet should adapt to the development of bitumen roads on which it is possible to drive faster. The good condition of vehicles is a prerequisite for a satisfactory safety level.

Enforcement

As seen in this report, it is utopian to think that drivers themselves will obey all traffic rules and respect speed limits. Enforcement is a necessary activity to be performed by the police.

Prerequisites for successful enforcement actions are:

- To have a system of legislation in place. The international conventions (*e.g.* the UNECE's Vienna Convention) and the experience of industrialised countries in developing traffic rules will be helpful.
- The police forces should be focussed on their essential safety role and respected by the population (*i.e.* no suggestion of corruption).
- Enforcement should apply to all members of the community, irrespective of their position and rank. Enforcement activities as recommended in this report (*e.g.* "anywhere anytime" action, quick procedures to minimise the time between the infraction and the sanction, the fairness of enforcement) also apply to developing countries.

Data collection and speed monitoring

Good data are essential for the development of targeted road safety measures. Developing countries should be encouraged to develop data collection system to have a better understanding of the road safety situation. They should also be encouraged to set up a speed monitoring system to assess the level of speeding on their road network.

12.4. Knowledge transfer

It has taken many years for industrialised countries to recognise that speeds must be moderated to reduce safety and other adverse impacts - and there is still a lot to do to convince the entire population.

It is to be expected that developing countries will also face difficulties in this field. Each country has its own problems related to its development, culture, religion etc. (including the attitude towards death). However, relatively little is known about the relationship between economic development, motorisation and increased speeding in less developed and developing countries.

Nevertheless, there is no doubt that road safety should be addressed in all countries, and that speed management is a key issue.

The experience of OECD/ECMT countries can therefore be very useful. Governments from industrialised countries should provide developing countries with the knowledge required to include speed management in their transport plans, taking account of lessons learnt from developing their own speed management policies. However, it is necessary for developing countries to adapt the measures to the culture and level of development of each country.

Dissemination of relevant advice from OECD/ECMT countries, including research findings from this JTRC report on *Speed Management* in particular, should therefore be valuable and help a wide group of less developed and developing countries deal with the major road safety problems they are facing.

12.5. Conclusions and recommendations

While the research does not exist to clearly quantify the situation of speeding in countries at different stages of development, motorization and road safety, the following overall conclusions can be drawn:

- Most parts of the world will experience less of a decrease in traffic fatalities per inhabitant in future than the OECD countries, and many less developed and developing countries will experience a substantial increase.
- Any overall trend towards increased speeding will affect the entire population and not only the particular groups (*e.g.* young people) that are likely to be over-represented in speeding behaviour.
- The highest numbers of potential drivers are in developing countries, especially Asia.
- Efforts should be made to reduce the impact of road safety risk on people in less developed and developing economies. The WHO-led UN Global Road Safety Collaboration is an important example of such efforts that should be supported.

It is recommended that:

- Countries co-operate internationally in efforts to reduce the impact of traffic safety on human health.
- Countries support the World Health Organisation-led United Nations Global Road Safety Collaboration initiative as one avenue for such co-operation.
- Efforts be made to gather better data on road safety and speed trends in developing and middle-income countries.
- International agencies (*e.g.* the WHO, World Bank) and organisations (*e.g.* PIARC) adapt the contents of this report to specifically address the problems of less developed and developing countries.
- International agencies (the World Bank and national aid agencies) always include a road safety component when carrying out road or road transport projects in developing countries.

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CHAPTER 13.

SUMMARY OF RECOMMENDATIONS

This Chapter summarises the main recommendations of the report for the attention of national, supranational and local governments. All the recommendations are based on findings from the research outlined in the report and the content and material provided in each of the chapters. Readers are invited to refer to the individual chapters for the reasoning and the background on each recommendation..

General recommendations

National governments should:

- Take action to reduce speeds on their roads.

- Take action to reduce speed dispersion (*i.e.* variation of speeds) in traffic flows.

- Consider speed management as a core element of their road safety strategy.

- Develop a comprehensive package of speed management measures. This package will vary from one country to another and will need to take into account the current levels of road safety performance in each country.

- Develop speed management measures on a very broad scale: for all types of vehicles, on all types of roads.

- Inform the public that speed management has the triple effect of improving road safety and the environment, and moderating energy consumption. With appropriate political support, speed management strategies can make a real contribution to achieving the three goals of improved road safety and environmental benefits, and more sustainable transport.

- Involve all stakeholders in achieving improved road safety outcomes, including: local authorities, car manufacturers, driving instructors, interest groups, motorists associations, etc.

Infrastructure (see chapter 4)

National and local governments should:

- Pursue the benefits possible from cost-effective road engineering measures. The aim is to achieve safe, "self-explaining" roads, with each road having a clear function (access, distribution or flow).

- To protect vulnerable road users and the general environment, particularly in dwelling areas, near schools and at pedestrian crossings, implement measures such as speed humps and road narrowings, which are cost-effective.

- On rural roads, the focus should be on creating more "forgiving" infrastructure by removing obstacles and making the roadsides safer. The construction of median barriers is a very effective method of reducing risks by separating traffic, although it is also a very costly measure.

- Consider lowering the speed limits when the infrastructure cannot be upgraded to the standard required by the existing speed limit.

Speed limits (see chapter 5)

National governments / supranational governments should:

- Consider harmonised speed limits across regions (*e.g.* Europe) to increase their credibility and their level of acceptance among the general public.

- Consider, at international (regional) level, a harmonised 80 km/h speed limit for heavy vehicles.

Governments / local authorities should:

- Determine appropriate speeds for all types of roads in the network.

- Review existing speed limits to assess whether they reflect the appropriate speed in relation to road function, presence of vulnerable road users, traffic composition, and road design and roadside characteristics.

- Set speed limits that are credible in the light of the road and the road environment and that take into account the physical resistance of the human body.

- Set local speed limits based on achieving lower than average accident risk. This recommendation anticipates a move away from the 85^{th} percentile speed approach. Some countries are using the mean speed of traffic as the basis for the local speed limits. However, while this approach better balances the speed at which the majority of drivers travel with the needs of other users, it does not take into account the actual level of risk.

- There should be a clear differentiation between speed limits on motorways and other roads in order to maintain the attractiveness of the motorway, which is the safest road category.

- In urban areas, set speed limits under 50 km/h and promote 30 km/h zones in areas where vulnerable road users (including children) are particularly at risk.

- Increase the use of variable speed limits, which can contribute to improved safety outcomes and public acceptance.

Signing, marking and driver information (see chapter 6)

National governments should:

- Take action to ensure that drivers are informed at all times of the appropriate speed limit. A traditional and cost-effective way is to use consistent roadside signing and road markings and much progress can still be made in their application.

- Encourage the wider use of emerging technologies which could allow the speed limits to be confirmed in other ways, such as on-board the vehicles.

National / local governments should:

- Conduct periodic audits of roads signs and markings both during the day and at night time (preferably giving priority to night time before day time audits)

Vehicle engineering (see chapter 7)

Governments should:

- Encourage the development of vehicle technologies which can help manage vehicle speed.
- Promote further research on Electronic Stability Control (ESC or ESP), Adaptive Cruise Control (ACC) and Event Data Recorders (EDR) to better evaluate their effects on road safety.
- Encourage the insurance industry to take more initiatives to curb speeding behaviour and reduce accident risk, and to evaluate their effectiveness
- Consider mandatory speed limiters for trucks and coaches, in countries where this is not the case.
- Strengthen enforcement to prevent illegal tampering with speed limiters for trucks – and illegal modification of motorcycle engines
- Encourage speedometer designs which give greater prominence to the legal range of speeds on the speedometer display, and less prominence to speeds over 130 km/h.

Education and information campaigns (see chapter 8)

Governments, including local governments, should:

- Target education and information to the public and policy makers about the problem of excessive and inappropriate speed. This is a prerequisite for the success of speed management actions. Such education and information should encompass the logical basis for the speed limit system, and the reasons for speed management measures, preferably by highlighting the positive outcomes of these measures. The production and dissemination of such information should be a continuous activity.
- Encourage manufacturers to utilise advertisements that do not glamorise speed.

Enforcement (see chapter 9)

National and local governments should:

- Ensure an appropriate level of traditional police enforcement and automatic speed control (including section control), which targets all road users.
- In the case of automatic enforcement, provide a system that makes the vehicle owner legally responsible for the violation when the driver cannot be identified[1].
- Encourage wider experience of enforcement achieved via section control.

1. In some countries (*e.g.* Germany), it is necessary to identify the drivers who committed the offence.

- Set speed limit excedence tolerance levels at a minimum (*e.g.* 5%), allowing only for possible inaccuracy of the measurement device. Setting higher tolerance levels gives drivers the wrong signal and makes the speed limit system less credible.

- Consult widely with all stakeholders and interest groups before wide-scale implementation of a speed camera programme.

- Accompany enforcement programmes with a system of public communication at national and local level.

- Set up a transparent system for the allocation of revenues generated by fines and re-invest these revenues in road safety activities.

National governments / supra national governments should:

- Establish bilateral or multilateral agreements to strengthen speed enforcement action in relation to speeding by foreign drivers.

New technologies, including ISA (see chapter 10)

Given the great potential benefits that such new technologies can bring, progressive implementation of ISA technologies is encouraged on a cost-effectiveness basis. In this respect, Governments should:

- Take actions to encourage the equipping of all new cars with manually adjustable speed limiters (where the driver can choose the maximum speed) and, as soon as practicable, voluntary informative or supportive ISA, to assist drivers to adhere to speed limits (both static and, eventually, variable limits).

- Reflecting the potential substantial safety benefits, give further consideration to mandatory ISA applications in the longer term, recognising and taking into account the changes in philosophies and liabilities that could be involved (for the supportive ISA systems)[2] .

- To help secure the potential benefits of the promising new ISA technologies, start developing and maintaining, in co-operation with relevant partners, the necessary digital speed limit databases.

Knowledge Transfer (see chapter 12)

National governments / supra national governments are encouraged to:

- Create partnerships with developing countries to ensure knowledge transfer from OECD/ECMT countries with good road safety performance on appropriate speed management policies and speed management measures.

2 For legal, liability and operational reasons, one country (Germany) has advised that it does not support the development and implementation of supportive ISA, whether voluntary of mandatory.

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ANNEX A.

EXAMPLES OF NATIONAL ROAD SAFETY PHILOSOPHIES AND STRATEGIES

This Annex contains brief descriptions of the road safety philosophies or strategies in some selected countries and the speed component of these. It is composed of the following sections:

A.1. Sustainable Safety in the Netherlands

A.2. Vision Zero in Sweden and other Nordic countries

A.3. Safe System in Australia

A.4. Road safety as one of the 3 top priorities in France

A.5. Road safety strategy in Great Britain

A.6. The EU road safety policy

A.1. Sustainable safety in the Netherlands

Sustainable Safety has been the leading road safety philosophy in the Netherlands since the early 1990s. In 1989, the Dutch government introduced quantitative road safety targets to give an extra impulse to the reduction of road traffic casualties: minus 50% fatalities and minus 40% serious injuries in 2010 compared with 1986. In absolute numbers this would mean 750 fatalities and 13 000 serious injuries in 2010. Soon, it appeared that these ambitious targets would not be met unless strong, innovative measures were taken. It was in this framework that, in the early nineties, the concept of sustainable safety was developed (Koornstra, 1991; see also Van Schagen & Janssen, 2001; Wegman *et al.*, 2006). The concept of sustainable road safety was adopted in the Dutch national policy on road transport and road safety in 1996 (Dutch Ministry of Transport 1996a; 1996b).

The aim of sustainable safety

The aim of sustainable safety is to create a traffic system and traffic conditions in which the probability of an accident is limited by means of an inherently safe road environment. Where accidents still occur, the conditions of the road, the roadside and the vehicle are such that serious injury is virtually excluded. In a sustainable safe traffic environment the road user and his fallibility and vulnerability is the starting point. All elements of the traffic system are maximally tuned to the capabilities and limitations of its users. The number of required actions and operations per time unit must be limited, so that the chance of errors is reduced. Hence, the road network and road infrastructure must be easy to understand and predictable, and more or less automatically elicit the required, safe behaviour. Vehicles must be made and equipped in such a way that the human task is simplified, human errors less probable and the consequences of errors less disastrous. Furthermore, road users must be adequately educated, informed and, where still necessary, controlled. The role of new technologies in the vehicle and along the road will become increasingly important as a means to support the road users with their tasks in traffic.

The five principles of Sustainable Safety

Currently, a sustainable-safe road traffic system is based upon five key safety principles: *functionality*, *homogeneity, predictability, forgivingness* and *state awareness*.

Functionality refers to the use of the road network. The road network should consist of a small number of road types or road categories, with each category having its own and exclusive function with its own and exclusive requirements regarding use and behaviour: monofunctionality. In a sustainable safe traffic system three traffic functions are distinguished:

- The flow function, a through road for long distance travel, at high speeds and, generally, for large volumes.
- The distributor function, opening up districts and regions containing scattered destinations.
- The access function, enabling direct access to properties alongside a road or a street.

Homogeneity refers to the elimination of large differences in speed, mass and direction. For example, roads with a flow function enabling high speeds for motorised traffic are closed for agricultural vehicles, since speed differences are too large. They are also closed for bicycles, since both speed and mass differences are too large. Opposing traffic streams are separated in order to avoid accidents between vehicles from opposing directions. The homogeneity principle reduces the need and possibility for complex manoeuvres.

Predictability, the third key principle of a sustainable-safe traffic system, is directly related to the road user. The layout and design of the road network and the individual roads in the network is clear and unambiguous and prevents uncertainties amongst road users. Road users immediately recognise the type of road they are travelling on; they know its function, they know what other types of road users they may expect to meet and what kind of behaviour is required. The prevention of uncertainty also refers to the consistency of design along a particular stretch of road, avoiding, for example, unexpected and narrow bends and an unexpected road narrowing.

Forgivingness – The principle of forgivingness has a physical component and a social component. The physical component is directly related to the vulnerability of the human body. If a crash is inevitable, the injury consequences should be kept to a minimum, for example by ensuring that there are hard and sufficiently wide obstacle-free shoulders. The higher the speeds, the wider the obstacle-free zone. Obstacles that cannot be removed can be screened off, *e.g.* by guard rails. The separation of opposing traffic streams at high speed roads, as required by the homogeneity principle is closely related to this. The social component of forgivingness refers to the interaction between road users. Road users need to be aware of the fact that other road users may not always behave as expected because they make an error or violate a rule intentionally. Road users (particularly the capable ones) may give more (physical and social) space to other road users to prevent that an error or violation immediately results in a crash.

State awareness – People differ in their task capability. For example, inexperienced road users and the elderly have poorly developed or declining competences and thus a lower task capability. Also, the task capability of a person changes over time. Someone has a lower task capability if he is tired, under emotional stress or under the influence of alcohol or drugs, for example. If road users are aware of their state and can correctly assess their capabilities and limitations, they can, for example, decide not to travel, to travel at another time of the day or to choose a less demanding route.

Implementation of Sustainable Safety and impact on speed management

The implementation of the sustainable safety measures requires long-term planning and a stepwise approach. Road safety policy in the Netherlands is largely and progressively decentralised and local, regional and national road authorities have their own responsibility, budget and decision making procedures. Therefore, the involvement and concern of all relevant parties is essential to realise a nation-wide implementation of sustainable safety. In December 1997, the Dutch Minister of Transport and representatives of the three main road authority bodies signed an agreement for a "start-up programme" on sustainable safety that covered the period 1998 – 2002. The programme consisted of a number of specific measures, speed related measures being an important part of it.

The homogeneity principle in particular resulted in speed related measures. The main idea is that in situations where motorised traffic and vulnerable non-motorised traffic use the same space, the speed of motorised traffic must be very low. Otherwise, if it is considered important that motorised traffic can flow at high speeds (*e.g.* for reasons of good traffic circulation), vulnerable road users have to be physically separated from motorised traffic. It is in this framework that the number and size of 30 km/h zones in residential and shopping areas, *i.e.* at places were pedestrians and cyclist mix with cars, have been drastically increased. Currently, around 50% of the potential 30 km/h zones are realised. Furthermore, 60 km/h zones in rural areas were introduced, mainly around rural settlements and recreational areas where there is also mixed traffic. At intersections, speed reduction measures have been taken by the construction of roundabouts and the use of raised areas and speed humps.

In addition, speed enforcement efforts have been increased substantially by the introduction of regional targeted enforcement projects in 1999. Each of the 25 regions in the Netherlands got eight additional persons of police staff for traffic enforcement only. They are paid by the revenues from the fines. Approximately two thirds of the available capacity was deployed in speed enforcement, mainly by means of fixed or mobile radar equipment. Between 1999 and 2003, the number of (administrative) fines for speeding was more than doubled from 3 million to 7.5 million per year.

The "start-up" programme was terminated in 2002. Recently, new actions have been taken, initiated by the Dutch road safety institutes, to bring about a revival of the sustainable safety way of thinking and the implementation of sustainable safety measures. Among other things, this has resulted in two publications about Sustainable Safety in the near future (Wegman and Aarts, 2005, 2006), as well as advanced discussions with relevant stakeholders to develop road safety plans on specific safety issues and to guarantee their commitment for specific actions. One of the issues that may get its own safety plan is speed management.

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A.2. Vision Zero in Sweden and other Nordic countries

Principles of Vision Zero

Vision Zero is the overall road safety philosophy in Sweden. Vision Zero is an image of a future where no one is killed or seriously injured in road traffic (SRA, 2002). Vision Zero forms the foundation for road traffic safety initiatives in Sweden, which has been established through a parliamentary resolution in October 1997. An important point of the Vision Zero is to get people interested in traffic safety matters and to create discussions and motivation. The parliamentary resolution has resulted in changes in road safety policy and also changes in methods of working with road traffic safety. The following is a summary of that resolution:

> *"The Swedish Parliament supports the Government's proposal for a new direction in road traffic safety based on 'Vision Zero'. The long-term goal for road traffic safety is that nobody is to be killed or seriously injured as a result of traffic accidents in the road transport system. To achieve this goal, the design and performance of the road transport system is to be adapted to the requirements of Vision Zero. Responsibility for road safety should be shared between road users and system designers, including road managers, vehicle manufacturers and people responsible for commercial road transport."*

The concept of Vision Zero has spread over other Nordic countries, such as Finland and Norway. For example in Finland, the National Safety Programme for 2001-2005 also states that the road transport system must be designed in such a way that nobody is killed or seriously injured on the roads. The Finnish Council of State of Traffic Safety officially adopted this Traffic Safety Vision of Finland in 2001. The ideas of Vision Zero find their way also outside Scandinavia, as is shown, for example, by the discussion of Vision Zero in the World report on road traffic injury prevention of the World Health Organization (WHO, 2004).

In its basis, Vision Zero is an ethical approach to road safety, an approach which is consistent with the values that characterise other areas of society, such as in the oil and nuclear industry and in other types of transport, *i.e.* rail, shipping and air. In a long-term sustainable road transport system as envisaged by Vision Zero, care of human life and health is considered to be more important than anything else.

An important element of Vision Zero is the requirement that people can use the road transport system without putting their lives or health at risk. Offering road users information on how the system can be improved, provides individuals with an opportunity to choose the safest alternative. For example, safety features could be a deciding factor in the choice between two cars. Furthermore, improved consumer information about safe traffic solutions increases consumer pressure on the market and speeds up developments in that field.

The present road transport system is often not adapted to the fact that people sometimes make mistakes. The perfect human being does not exist. These days, a simple wrong decision in road traffic is all too often punished by death. According to Vision Zero, road safety assumes that everything possible is done to prevent serious injuries and deaths in road traffic. While efforts are made to prevent accidents, the design of the road transport system must take into account that people make mistakes and that traffic accidents cannot be completely avoided. Therefore, the design of the system should take account explicitly of an individual's biological tolerance to physical injury when an accident happens, *i.e.* how much force a body can tolerate and survive.

Role of speed management in Vision Zero

This latter element of Vision Zero makes speed a central element (SRA, 2001). For example, there are established scientific speed limit values that are based on the current design of cars and roads. These include:

- Most unprotected road users survive if a car travelling at 30 km/h hits them.

- Most unprotected road users are killed if a car travelling at 50 km/h hits them.

Based on this type of knowledge, 30 km/h speed limits in built-up areas have been introduced on a fairly large scale. The idea of 30 km/h speed limits in built-up areas is not new, but work to achieve Vision Zero has focused on the fact that this is the maximum permissible speed if pedestrians and cyclists are to survive a collision.

Furthermore,

- A safe car can protect occupants up to 65-70 km/h in a head-on collision, and up to 45-50 km/h in a side collision, assuming all car occupants are wearing seat belts.

Another typical example to illustrate the way of thinking in Vision Zero is the choice between traffic lights or roundabouts at an intersection. If the goal is to reduce the number of accidents, then traffic lights are the best solution. The number of accidents is reduced, but accidents that still occur often result in serious injury or death. If the goal is to avoid serious injuries, as it is in Vision Zero, then a roundabout offers the best results. There may be more accidents, but the resulting injuries will be minor as the accidents occur at different collision angles and at lower speeds. So roundabouts have become a more common traffic solution at intersections, particularly in built-up areas. They have existed in the past, but since the introduction of Vision Zero their key role in traffic safety has been highlighted.

A new feature is the 2+1 roads with median cable barriers, a type of road only found in Sweden. A trial began in summer 1998, when the first median barrier was erected along a stretch of road with a large number of fatal accidents. Despite initial scepticism, this solution has proven very effective in preventing head-on collisions. The erection of central barriers on roads has accelerated since 2000.

Major investments have been made to lessen the damage caused by cars driving off the road. Guardrails have been erected and dangerous objects, such as boulders and trees, have been removed from roadside areas or protected.

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A.3. Safe System in Australia

Australia's National Road Safety Strategy 2001-2010 has the target of reducing the annual number of road fatalities per 100 000 population by 40%, from 9.3 in 1999 to no more than 5.6 in 2010. Australia's National Road Safety Action Plan 2003-2004 recognises the important role that more effective speed management can play in achieving the target. It nominates the following areas for emphasis: improving compliance with speed limits; publicity; enforcement; the reduction of urban speed limits below 60 km/h on roads with high pedestrian activity; and the reduction of rural speed limits on roads with above average crash risk.

In Victoria, the "Safe System" philosophy has been adopted. This is built on the premise that crashes are going to happen even with a focus on prevention. Accordingly, the road transport system needs to be designed and structured so that in the event of a crash, the people involved would not suffer fatal injuries. The system should also lessen the risk of serious injury from a crash. The key relevant transport system components under the Safe System approach are the vehicles, the road infrastructure and safe speeds. The objective is to utilise these components to minimise the probability of death (or serious injury) as a consequence of a road crash. The Safe System approach is one of the key strategies in Victoria's efforts to reduce the road toll.

Austroads, the association of Australian and New Zealand road transport and traffic authorities, has also adopted the Safe System approach and has recommended it to all Australasian jurisdictions.

Speed management within the Safe System approach in Victoria

Effective speed management is a very important element of the Safety System approach. Over the last few years the government of Victoria has adopted a number of measures in a multi-pronged attack on the road toll:

- The default speed limit for urban areas was lowered to 50 km/h in 2001. This limit applies to all streets other than arterial roads.

- In those country town centres where there is a high level of pedestrian/vehicle conflict, 50 km/h limits have also been introduced on arterial roads or highways.

- In urban strip shopping centres (usually on arterial roads with a 60 km/h limit) where there has been a history of pedestrian-related crashes, a time-based variable speed limit of 40 km/h has been introduced for those periods during the day when pedestrian activity is higher.

- Fixed speed cameras have been installed on one of Melbourne's high speed urban motorways to support a system of variable speed management, which is aimed at reducing incidents, crashes and delays.

- The speed enforcement threshold applied by police in Victoria has been reduced for all speed limits, in recognition of the improved accuracy of both vehicle speedometers and speed measuring equipment. This has had the effect of lowering average travel speeds in Metropolitan Melbourne.

- Cameras which are able to record both speed and red light violations have now been installed at some 80 intersections throughout Melbourne. They will progressively become operational in the 04/05 year. Speed cameras generally are being put to greater use, particularly in locations with a crash history.

- The road safety advertising campaigns which the Transport Accident Commission commenced in 1992 have now been focused on particular areas with poor accident records, using local news media and roadside advertisements.

- In a bid to curb excessive speeding, loss of licence now applies where the speed limit is exceeded by more than 25 km/h (previously 30 km/h). In addition, the break points for minimum higher demerit points were lowered in late 2001, *e.g.* points are now increased when detected more than 10 km/h over the limit (previously 15 km/h).

- Recent advances in technology have led to the development of radar speed detection devices that can be used by moving Police vehicles. This equipment has been deployed in rural areas.

- A point-to-point camera system, which enables the average speed to be measured between two locations on the rural road network for enforcement purposes, is being trialled.

- An experimental Safecar has been developed which is 'aware' of the relevant speed limit (using GPS) and warns the driver with an audio device and exerts a resistance on the accelerator pedal if the driver exceeds the limit.

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A.4. Road safety as one of the 3 top priorities in France

Recent evolution in road safety policy in France

The French road safety policy is defined at a national level. An Inter-ministerial Commission on Road Safety, the CISR, consisting of members from the different Ministries, defines the actions to be carried out in the different areas of road safety. While the number of road fatalities had been declining over the last 30 years, recent developments were less positive. Therefore, on the 14th of July 2002, the French President announced that the "fight against road unsafety" would be one of his three main objectives over the next 5 years. This reflects the extent to which road safety has become an area of concern in France.

In December 2002, the CSIR decided on a new programme. In addition to strengthening enforcement activities and other preventative measures, the programme aimed to mobilise all actors in the field of road safety. A law on road safety was adopted in June 2003, specifying the various measures to be taken. One of its most important articles calls for improving traffic rule compliance by intensifying police enforcement and related penalties. An immediate and significant decrease in the number of road fatalities and injury accidents followed these initiatives (see Table A.1.).

Table A.1. **Decrease in fatalities and injuries following increase in police enforcement and penalties**

	2001	2002	2003	2004	2005	Change 2001-2005
Fatalities[1]	8 160	7 655	6 058	5 530	5318	-35%
Injury accidents	116 745	105 470	90 220	85 390	84 525	-28%

The new road safety actions are worth examining here in more detail, because of their strong impact on safety. These are related to different areas:

Intensifying speed enforcement and penalties to improve rule compliance

The intensification of enforcement and penalties was realised through the introduction of an automatic enforcement and penalty system for speed violations. This will be extended in the near future to include red light running. The first speed cameras were installed in November 2003 and, by the end of 2004, 400 speed cameras (232 fixed and 168 mobile) were in use. It is expected that 1 000 systems (700 fixed and 300 mobile) will be in place by the end of 2005. The enforcement process, from control up to the fine, is now fully automated, with a rapid follow-up from the violation to the sanction, which is more pedagogic. The penalty system was also modified, with the penalties for minor offences being fixed amounts, and those for the more serious offences (alcohol +0.8g/l) being increased. Violation detection has become better and sanctions more severe for recidivists and some swindlers.

1. Fatalities within 30 days.

Mobilising partners and developing new approaches for road safety

It is recognised that the French state cannot act and succeed alone, as many of the measures and actions require the involvement of other partners and actors. Only in this way is it possible to create a real synergy of actions, to develop knowledge and to modify behaviour in a structural way. The major partners in road safety are the local authorities: cities, departments and regions. The fight for road safety is part of the country's wider security policy. As such, road safety must be not only part of the local policy for accident prevention, but also of local policy for crime prevention. Thus, co-ordination between the national government and the regional and local authorities will be strengthened. The introduction of regional road safety action plans (Plans Départementaux d'Actions de Sécurité Routière, PDASR) are considered a good way to increase the involvement of the local and regional actors, for example in the field of road safety engineering.

These recent priority actions in the French road safety policy come on top of previous safety actions in the field of road users, vehicles and road infrastructure, which have been applied over many years. However, this recent emphasis on enforcement activities seems to have had a substantial effect on the behaviour of a large majority of road users.

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A.5. Road safety strategy in Great Britain

Tomorrow's Roads – Safer for Everyone

Great Britain has long been recognised as having a good road safety record and making good progress in reducing the number of road traffic injuries. Despite this success, reducing road traffic injuries further remains a Government-wide priority at both the national and local levels. Great Britain's national road safety strategy, *Tomorrow's Roads – Safer for Everyone,* launched by the Prime Minister in March 2000, set out a new framework for delivering further improvements in road safety over the next decade. Based upon previous research and statistical evidence, the strategy established the following, new, long-term 10-year casualty reduction targets to be achieved by 2010.

Compared with the baseline average for the calendar years 1994 to 1998:

- A 40% reduction in the number of people killed or seriously injured (KSI) in road accidents.
- A 50% reduction in the number of children[1] killed or seriously injured (Child KSI) in road accidents.

Casualty data for 2005 shows that the overall number of KSIs has reduced by 33%. This means that some 15,500 fewer people are now being killed or seriously injured on Great Britain's roads each year. Even better progress is being made on reducing child casualties. The number of children casualties has reduced by 49%. This equates to 3 380 fewer children killed or seriously injured each year.

At the Road Safety Strategy's core is a major focus on three areas – driver behaviour, enforcement, and a safer driving environment. This is often characterised as 'the three E's': education, enforcement and engineering. This focus also underpins Great Britain's approach to speed management, where the three elements come together at both the national and local level to encourage and assist people to drive and ride at safe legal speeds.

Safer speeds

The inclusion of 'Safer speeds' as one of ten key themes within the Road Safety Strategy reflects the important contribution that effective speed management is making towards delivery of the 2010 casualty reduction targets.

Research undertaken by TRL in the 1990s showed excessive speed to be a contributory factor in a third of all road accidents in Great Britain. Since 1999, certain police forces have recorded 54 possible contributory factors to accidents. Although not conclusive, analysis of this data between 1999-2002, published in September 2004, has shown that "excessive speed" was identified as contributing to 12% of all accidents, 18% of serious injuries and 28% of fatal accidents. In the case of fatal accidents, excessive speed was the most frequently recorded factor. This implies that excessive speed contributed to some 1 000 deaths and over 35 000 serious injuries each year.

1. In Britain, children are defined as being those under the age of 16.

Involvement of stakeholders

In both speed management, and across the overall Strategy, the Government plays a central role. However Great Britain's success is also essentially dependent upon active involvement of many delivery agents and stakeholders across Great Britain, both within and outside Government. Local authorities, working in co-operation with the police, are ultimately responsible for delivering effective speed management strategies at the local level and have adopted the overall 2010 casualty reduction targets. Local authorities have been given the necessary powers to introduce speed management schemes involving a wide range of measures, including traffic calming, 20mph zones and use of vehicle activated signs.

Many effective working partnerships have been established at both national and local level. A Rural Safety Management Group, consisting of key Government stakeholders, the police, local authority representative groups and other key stakeholders and practitioners, is helping to develop and progress a number of rural speed management policies at the national level. At the local level, highway authorities and the police have come together to form wider Casualty Reduction Partnerships or, by uniting with magistrates courts, to operate Local Safety Camera Partnerships.

The "Safer speeds" commitments in the road safety strategy reflect the conclusions of a detailed review of Great Britain's speed management policies undertaken in the late 1990's and published in conjunction with the strategy. Recognising that a sensible balance must be achieved between the need to travel and improving quality of life, Great Britain's speed management strategy is now seeking to take better account of the contribution of appropriate speeds to environmental and social objectives, as well as to road safety.

Increasing public acceptance of, and therefore self compliance with, speed limits is a key focus of speed management strategies. Working within the overall national speed limit framework, local authorities have the flexibility to set local speed limits that are right for the individual road, reflecting all local needs and considerations. Local speed limits are determined using a series of underlying principles. In August 2006, the Government published new guidance on the setting of local speed limits, developed through the Rural Safety Management Group, and underpinned by further research by TRL. With the research having provided a much better understanding of the speeds actually being driven on a range of rural roads, the new guidance introduces a fundamental change with appropriate local speed limits to be based upon mean speeds, rather than the 85th percentile speed. The updated guidance also introduces the use of an analytical Speed Assessment Framework tool to assist local decision making and promote greater consistency in the setting of speed limits on single carriageway rural roads where inappropriate speed is a factor in many accidents, especially those involving fatality.

Speed limits prove more effective when introduced as part of a wider speed management package, including other measures such as engineering and landscaping changes to raise the driver's awareness of their environment, education, driver information, training and publicity. Awareness of the dangers of speed and its impact on injury severity is co-ordinated at the national level through the Department for Transport's *Think!* national publicity campaigns.

The Government is highly supportive of the use of safety camera technology as one of the options available for addressing road safety concerns. Deployed in accordance with strict criteria, and only where there is a history of speed related accidents, the National Safety Camera Programme is proving highly effective at reducing speed related accidents. An independent three-year evaluation report published in June 2004 provides convincing evidence of what happens when excessive speed is targeted by enforcement. An independent four year evaluation report published in December 2005 shows convincing evidence what happens when excessive speed is targeted by enforcement.

Nationally, the results of the three years of activity in 38 police force areas of Great Britain found that, at camera sites, the number of people killed or seriously injured fell by 42%, and that the number of personal injury collisions (all injury accidents) fell by 22%. Furthermore a 6% reduction in average speed at camera sites was seen, a 30% reduction in the number of vehicles exceeding the speed limit and a 43% reduction in those exceeding the limit by more than 15 mph.

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A.6. The EU road safety policy

The European Union is very much aware of the importance of transport as well as of its negative consequences. Transport is an important sector of the European economy, worth 10% of the gross domestic product in the EU, and employing approximately 10 million people (EC, 2001). The negative consequences, including traffic congestion, road accidents, and environmental pollution are becoming increasingly unbearable, for both the users and the economy.

The EU has set down its transport policy and its road safety policy up to 2010 in two major documents:

- The White paper on European transport policy for 2010: Time to Decide (EC, 2001).
- "The European Road Safety Action Programme: Halving the Number of Road Accident Victims in the European Union by 2010: A Shared Responsibility" (EC, 2003).

The main challenges when aiming to halve the number of road fatalities, as identified by the EC in its action programme, are:

- Excessive or inappropriate speed, a factor in one third of fatal and serious accidents.
- Alcohol, drugs, non wearing of seat belt.
- Lack of sufficient protection on-board the vehicle in the event of an impact.
- High-risk sites (black spots).
- Non-compliance with driving and rest times by professional drivers.
- Poor visibility of other users / insufficient vision for driver.
- Particularly high risk groups: young people (15-24) and elderly, in particular pedestrians.

Most of these causes and challenges have a direct or indirect link with speed and speeding.

E-Safety

A recent development, stimulated and facilitated by the European Commission is the e-Safety expert group (IP /02/1304). This expert group, consisting of approximately 40 members, started in 2002. It is a public-private partnership involving the car industry, communications sector, the transport sector, and safety experts, among others. E-Safety refers to the use of new technologies for information and communication (TIC) to improve road safety, support road users in their driving task and mitigate the consequences of human error. The expert group has come up with several recommendations for the use of TIC in order to improve safety. While the majority of new technologies for information and communication for road transport do not have a safety aim, there are numerous research projects on safety applications all around the world. The first applications have already appeared on the market, such as the speed limiters in curbs, tested in Japan and, of course, the intelligent speed adaptation (ISA), tested in particular in Sweden, the Netherlands, Great Britain and France.

Others applications are being studied, both for active safety to prevent accidents (systems for improved dynamic characteristics of vehicles, improved braking performance, obstacle detection, information on the state of the road, lane departure warning, etc.), as well as for passive safety to limit consequences of an accident (airbags, safety belts, emergency calling systems, etc). In Europe, current research focuses on particular technical elements of new technology systems, such as sensors, telematics, and in-vehicle architecture. Within the 6th framework research programme of the European Commission, specific attention was given to a global system approach which will include all elements.

Without doubt, e-safety will expand enormously in the next years. Nevertheless, there are several questions that still need to be answered. One example is the question regarding the development of autonomous in-vehicle systems in comparison to systems that require an interaction between the vehicle and the road side, and the subsequent consequences for responsibility and liability issues. Another example is the question how to deal with the fact that the development of e-safety applications must progress from now on, even though many of the systems will be effective in 20 or 30 years only.

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ANNEX B.

SUMMARY OF RESPONSES TO THE QUESTIONNAIRE

Introduction

To collect updated information from OECD/ECMT countries about their speed management practices, the Working Group undertook a survey in 2004 — which was updated in 2006 —, based on a questionnaire that was sent to all OECD/ECMT countries.

The following 23 countries responded to the questionnaire: Australia, Austria, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Japan, Korea, Mexico, Netherlands, Norway, Poland, Portugal, Russian Federation, Sweden, Switzerland, the United Kingdom and the United States. The Slovak Republic also provided some data.

This annex summarises the responses to the questionnaire. It is composed of four main parts:

B.1. Current speed limits

B.2. Proportion of drivers above speed limits

B.3. Recent evolution in public's attitudes towards speeding

B.4 Enforcement of speed limits

B.1. Current speed limits

Speed limits for light vehicles

Motorway (see table B.1)

Speed limits on motorways vary in the responding countries from 90 km/h to 130 km/h. The speed limit in Iceland is 90 km/h, as well as in other countries such, as Norway and Korea, under certain conditions. The maximum speed limit found in Austria, France, Denmark, the Czech Republic and the Slovak Republic, is 130 km/h. Several countries make a distinction between urban motorways and interurban motorways. In these cases, the speed limit is lower in urban areas. On some Germany motorways, there is no speed limit. However, drivers are advised not to exceed 130 km/h.

Main highways (undivided carriageway) and rural roads (see table B.2)

Speed limits on *main highways* usually vary from 60 km/h (Korea on 2x1 lane-roads) to 110 km/h (Greece, Mexico, some states in the United States and some roads in Sweden). Most countries have a speed limit of 90-100 km/h.

On *rural roads,* speed limits vary from 60 km/h (on one-lane roads in Korea) to 100 km/h (State of Victoria in Australia, Austria, Germany, Greece). Some states in the United States have a 70 mph (113 km/h) speed limit. Most of the countries have a speed limit of 80-90 km/h.

Urban (Arterial roads), local and collector streets (see Table B.3)

Speed limits on *arterial roads* vary from 48-50 km/h to 90 km/h. On local and collector streets, speed limits vary from 30 km/h to 80 km/h (on 2-lane streets in Korea) and 50 km/h is a common limit for a majority of countries. 30 km/h zones are also widely used in the responding countries.

Speed limits for heavy vehicles (see Table B.4)

Almost all countries have differentiated speed limits for heavy vehicles. This is, however, not the case in Canada or in most states of the United States. In Canada, there is, however, a differentiated speed limit for school buses, which are not allowed to go faster than 90 km/h on highways with posted limits of 100 or 110 km/h.

All responding countries, with the exception of Canada, Mexico, Norway, Russia and the United States, have compulsory speed limiter systems for certain categories of heavy vehicles. In the European Union, a Directive (EC 2004/11) requires speed limiters on trucks over 3.5 tons and vehicles (including buses/coaches) with more than 9 seats. Speed limiters are set at 90 km/h or 100 km/h depending on the type of vehicles.

Differentiated speed limits for weather conditions, young drivers, nighttime, near schools

Only a limited number of countries have differentiated speed limits for certain weather. In some countries, there might be advisory speed limits displayed on matrix signs.

Rain

The following countries have a differentiated speed limit for rainy conditions: Canada, France, Japan, Korea, United Kingdom (advisory limit).

Fog

The following countries have a differentiated speed limit for fog conditions: Canada, France, Japan, Korea, United Kingdom (advisory limit).

Snow

The following countries have a differentiated speed limit for snow conditions: Canada, France, Japan, Korea, United Kingdom and some states of the United States.

Darkness/nighttime

Austria (on some motorways, to reduce noise level), Korea, United States (2 states: Montana and Texas) have differentiated speed limits at nightime.

Wintertime

Finland and Sweden have differentiated speed limits during the Winter season.

Wind

The State of Victoria in Australia, applies, on an exceptional basis, differentiated speed limits in case of heavy winds.

School zones (see also the section on variable speed limits)

In the United States, the school zone speed limit varies by road type and state; however 25 mph (40 km/h) is common. In Australia, the speed limit in front of schools is either 60 or 40 km/h. In Canada, reduced speed limits in school zones are common.

Differentiated speed limit for young and novice drivers (see table B.5)

Of the responding countries, only France and Ontario (Canada) apply a differentiated speed limit for young or novice drivers. (See OECD/ECMT report on Young Drivers Risks, published in 2006, for more information on young drivers risks countermeasures).

Variable Speed Limits

Almost all countries have implemented variable speed limits. These can be set automatically (based on certain parameters such as the level of traffic) or manually by an operator.

Variable speed limits are mainly applied on motorways or main highways with heavy traffic. They are often used also in tunnels and bridges. In Norway and the United States, variable speed limits are applied in school zones, at times when children are entering or exiting schools. In the State of Victoria, there are variable speed limits near shopping centres during periods of high pedestrian activity.

The reasons for applying variable speed limits are usually to enhance safety in particular conditions (work zones, in case of accidents, in case of heavy traffic) and to ensure better fluidity of traffic. Some countries (*e.g.* Sweden, Finland, United States) mentioned variable speed limits also as a tool to increase credibility of speed limits and to make them more acceptable to the public. Variable speed limits are also applied in some countries in the event of pollution peak.

Recent changes in speed limits (see Table B.6)

Table B.6 illustrates the recent changes in speed limits in the responding countries.

There has been a reduction in the speed limit in some urban areas in: Australia (Victoria), Canada, Finland and Poland.

Finland has widened the application of (reduced) 80 km/h limit in winter time on undivided main roads.

Several countries (Korea, Canada, some US States, Denmark, Norway) have increased speed limits, mainly on motorways, due to public pressure and improvements in design standards:

Ireland moved to a metric system and applied, since January 2005, speed limits in km/h.

Future changes in speed limits expected

Urban areas

Norway is planning to extend 30 km/h zones.

Motorways

Higher limits for motorways are under consideration in *Canada* (in one province, 110 km/h on roads upgraded for higher capacity), *Austria* (130 to 160 km/h in conjunction with variable speed limit signs and increased enforcement, possibly by section control), the *Czech Republic* (where there is a lobbying for no speed limits on motorways) and the *United States* (in four states, where the limit increase from 70 to 75 mph in Kansas, from 75 to 80 mph in Arizona and from 65 to 70 mph in Oregon and Iowa). The *Netherlands* is experimenting with 80 km/h sections on limited sections of motorway close to built-up areas, with automated section control enforcement.

Rural roads

The *Czech Republic* may increase speed limits on **rural roads** from 90 to 100 km/h. *France* is developing a new concept for “quiet roads” in rural areas, and may expand the application of variable speed limits, specifically lower limits when air pollution levels are too high.

Other considerations

Increased enforcement including automated enforcement with section control, increased fines and higher demerit point levels are expected to accompany most of the above changes.

Sweden is considering additional speed limits at intervals of 10 instead of 20 km/h to achieve better adaptation of traffic speeds to local road design.

Table B.1. **Current speed limits on motorways for passenger cars**

Country	Speed Limit	Comments
Australia (Victoria)	110 – 100 km/h	110 km/h is restricted to high standard, low volume, freeways with a good safety record.
Austria	130 km/h	
Canada	90 km/h, 100 km/h, 110 km/h typically 100 or 110 km/h 80-90 km/h (urban expressways, other than provincial highways) and parkways).	Limits vary within and between provinces. In Quebec, there is a minimum speed limit of 60 km/h.
Czech Republic	130 km/h	80 km/h for motorways in urban areas.
Denmark	130 km/h (110 km/h – 90 km/h)	General speed limit. On approx. 50% of the motorway network there is a local speed limit of 110 km/h (90 km/h in a few places).
Finland	120 km/h	100 km/h in winter.
France	130 km/h or 110 km/h	130 km/h in rural areas (with some exceptions). 110 km/h in urban areas or for the so-called “routes pour automobiles”.
Germany	None (on some motorways).	It is recommended not to drive beyond 130 km/h.
Greece	120 km/h	Speed limit for motorcycles under 125 c.c. is 70 km/h.
Iceland	90 km/h	
Ireland	120 km/h	Ireland shifted to the metric system in 2005.
Japan	100 km/h (national expressways).	
Korea	Freeways: max.100~110km/h min. 50km/h Motorway: max, 90km/h, min 50km/h depending on road condition.	
Mexico	110 km/h	
Netherlands	120 km /h - 100 km/h	100 km/h on approximately 25% of the Dutch motorway network near cities and towns, mainly in the Western part of the Netherlands.
Norway	90 km/h or 100 km/h	100 km/h, if lighting and physical barrier in the middle.
Poland	130 km/h	110 in divided carriageway.
Portugal	120 km/h	
Russia	110 km/h	Minimum : 40 km/h Motorcycles: 90 km/h Light vehicles with trailer: 90 km/h
Slovak Republic	130 km/h 80 km/h in urban areas.	
Sweden	110 km/h sometimes 90 km/h rarely 70 km/h.	120 km/h will be tested with variable signs.
Switzerland	120 km/h	60 km/h (minimum speed)
United Kingdom	70 mph (113 km/h)	
United States	Varies by State: Rural: 65-75 mph (104-120 km/h) Urban: 55-70 mph (88-113 km/h)	Nominal 70 mph (113 km/h) – Rural 65 mph (104 km/h) – Urban

Table B.2. **Current speed limits on main highways and rural roads for passenger cars**

Country	Speed Limit on main highways	Speed Limit on rural roads	Comments
Australia (Victoria)	100 km/h	100 km/h	Sections with low standards and very poor safety record can be reduced to 90 or 80 km/h
Austria	100 km/h	100 km/h	
Canada	80 km/h, 90 km/h, 100 km/h	70 km/h to 100 km/h on paved roads (Typically 80 km/h and 90 km/h)	Limits vary within and between provinces and territories.
Czech Republic	90 km/h	90 km/h	
Denmark	80 km /h	80 km /h	It is possible locally to lay down a lower or higher speed limit. However, the highest speed limit cannot exceed 90 km/h.
Finland	100 km/h or 80 km/h (depending on road characteristics)	80 km/h	During winter, some 100 km/h roads are limited to 80 km/h.
France	90 km/h	90 km/h	No limitation for "lieux dits" (very small villages).
Germany	100 km/h	100 km/h	
Greece	110 km/h	70-100 km/h 50 km/h	For rural roads, 50 km/h when crossing small towns/ villages, etc.
Iceland	90 km/h	90 km/h / 80 km/h	Paved roads/gravel roads.
Ireland	100 km/h	80km/h	Ireland shifted to metric system in 2005.
Japan	40, 50, 60 km/h (national highways)		
Korea	One lane :60km/h Two lanes or more 80km/h	One lane :60km/h Two lanes or more: 80km/h	
Mexico	110 km/h	100 km/h	
Netherlands	100 km/h	80 km/h	60 zones in rural areas (settlements/recreational areas) .
Norway	80 km/h	80 km/h	
Poland	100 km/h	80 km/h	
Portugal	100 – 90 km / h	90 km/h	100 km/h on road reserved to motorised traffic. 90 km/h – all other rural roads.
Russia	90 km/h	90 km/h	70 km/h for light vehicles with trailer.
Slovak republic	90 km/h	90 km/h	
Sweden	Mostly 90 km/h sometimes 70km/h or 110 km/h	Mostly 70 km/h also 90 km/h	70 km/h is the general speed limit outside built up areas. Due to the general conditions of a road the national Road Administration can decide that the speed limit shall be 90 or 110 km/h. The Regional governmental authorities may decide that the speed limit locally shall be lower than 70 km/h, or lower than 90 or 110 km/h if that speed limit has been decided.
Switzerland	80 km/h	80 km/h	
United Kingdom	60 mph (97 km/h)	60 mph (97 km/h)	
United States	Varies by State 55-70 mph (88-113 km/h)	Varies by State 55-70 mph (88-113 km/h)	Nominal: 55 mph (88 km/h)

Table B.3. **Current speed limits on urban arterial roads, local and collector streets (all vehicles)**

	Urban : arterial roads	Urban : local and collector streets	Comments
Australia (Victoria)	80, 70, 60 km/h	50 km/h	
Austria	50 km/h	50 km/h 30 km/h zones and 40 km/h streets in residential areas	
Canada	40 to 80 km/h Typically 50 and 60 km/h	30, 40, 50 km/ 40 and 50 km/h are the most common	These speed limits were provided by Toronto, but are typical practice throughout Canada: 50 for minor arterial roads 40 for most local and collector streets 30 with traffic calming (*e.g.* speed humps). Speed limit of 40 km/h is typical for school zones during school opening hours.
Czech Republic	50-60 km/h	50 km/h	70 km/h very rarely on some parts of main arterial roads.
Denmark	50 km/h	50 km/h	General speed limit. It is possible locally to lay down a lower or higher speed limit.
Finland	50 km/h	30 - 40 – 50 km/h	In some cases for arterial roads, also 60 km/h (special arrangements for pedestrians). For local and collector streets, more than 50% of streets < 50 km/h.
France	50 km/h	50 or 30 km/h	In some rare cases, the limit is 70 km/h on arterial roads. For local streets; The 30 speed limitation is set up in specific zones, with a peculiar design.
Germany	50 km/h	50 km/h	
Greece	90 km /h (Full access control (interchanges) 70 km/h (Primary roads (fully signalised) 50 km/h (other)s	30 (local streets) 40-50 (collector streets)	
Iceland	50-60 km/h	30 km/h (local) 50 km/h (collector streets)	For local streets: 30 km /h zones.
Ireland	50-80 km/h	50 km/h	Ireland shifted to metric system in 2005.
Korea	One lane :60km/h Two lanes or more: 80km/h	One lane :60km/h Two lanes or more: 80km/h	

Table B.3. (Contd.) **Current speed limits on urban arterial roads, local and collector streets**

	Urban : arterial roads	Urban : local and collector streets	Comments
Mexico	80 km/h	20-60 km/h	For local street, the limit depends on activities developed in urban zone.
Netherlands	50-70 km/h	50 km/h	For arterial roads: 70 km/h mainly at 4 lane urban ring roads. 30 zones in residential areas.
Norway	50 km/h	30-50 km/h	Sometimes 60 or 70 km/h where no accesses. For local streets: 50 km/h is the general speed limit. 30 or 40 km/h is often used on access roads in dwelling areas and, increasingly, in city centres.
Poland	50 km/h	50 km/h	(60km/h between 23 pm and 6 a.m.)
Portugal	50 – 90 km/h	50 km/h	Some urban divided arterials have speed limit of 80 or 90 km/h, as set by their own local road administration.
Russia	60 km/h	60 km/h	On Arterial roads, regional governmental authorities can decide to increase the limit if the road conditions provide the necessary safety level.
Slovak Republic	60 km/h	60 km/h	Usually 30 km/h or 40 km/h in the city centres.
Sweden	50- 70 km/h	30 - 50 km/h	50 km/h is the general speed limit in built up areas. The municipalities can decide that the speed limit shall be other than the general speed limit. This speed limit can be either higher or lower.
Switzerland	50 km/h	50 km/h	
United Kingdom	30 -40 mph (48-64 km/h)	20-30 mph (32-48 km/h)	For arterial roads: Most urban main roads are 30 mph, but some through-routes, including divided roads, are 40 mph. Local urban roads are normally 30 mph. Some minor residential roads are 20 mph, including 20 mph zones which, by definition, must have traffic calming measures.
United States	Varies by State 30-55 mph (48-88 km/h)	Varies by state Local streets: 25-35 mph (40-56 km/h)	

Table B.4. **Speed limits for heavy vehicles and use of speed limiters**

Country	Type of Vehicles / Weight	Speed limits	Speed limiters Compulsory Y/N
Australia (Victoria)	Buses > 14.5 t. Prime Movers > 15 t All heavy vehicles > 20 t.	100 km/h on rural freeways (instead of 110).	Yes (set at 100 km/h).
Austria	Trucks > 3.5 t	Motorways: 70 km/h for lorries without trailer 60 km/h with trailer 70 km/h for semi trailer 80 km/h for coaches	Yes EU Directive.
Canada	School buses No differentiated speed limits for trucks, except very large commercial vehicles (length > 6.5 m) on steep hill descents.	90 km/h on 100-110 km/h highways Example: Posted limit 80. Large trucks restricted to 50.	No.
Czech Republic	Coaches, more than 8 persons. Trucks>7.5 t	Motorways: 100 km/h (instead of 130)	Yes EU Directive.
Denmark	> 3.5 tons	50 km/h (urban) 70 km/h (rural) 80 km/h motorways)	Yes, EU Directive.
Finland		80 km/h trucks 100 km/h coaches	Yes, EU Directive.
France	> 3.5 tons > 12 tons	110 km/h on motorways (instead of 130 km/h) 80 km/h on other non urban roads (instead of 90 km/h) 90 km/h on motorways 80 km/h on other non urban roads; 60 km/h for heavy vehicles with a trailer.	YES, EU Directive.
Germany		89 km /h on motorways	Yes, EU Directive.
Greece		60 -90 km/h	Yes, EU Directive.
Iceland		80 km / h on motorways, highways and rural roads for heavy vehicles and 80-90 km/h for coaches.	Yes, since 1996. Set at 90 km/h for heavy trucks and at 100 km/h for coaches.
Ireland	t > 3.5 tons (for trucks)	80 km/h	Yes, EU Directive.
Japan			Yes, Since 2003 Speed limiters set at 90 km/h.
Mexico			No. Tachographs are used as a speed control measure.
Netherlands	> 3.5 tons	80 km/h	Yes; EU Directive. Set at 85 km/h for trucks and at 100 km/h for coaches.

Table B.4. (Contd.) **Speed limits for heavy vehicles and use of speed limiters**

Country	Type of Vehicles / Weight	Speed limits	Speed limiters Compulsory Y/N
Norway		80 km/h (on rural roads with higher speed limits).	No.
Portugal	> 3.5 tons	Different limits for trucks / truck + trailers and coaches.	Yes, EU Directive.
Russia	Trucks > 3.5 t Buses/coaches> 8 passengers.	Motorways: 90 km/h (instead of 110 km/h). Main highway and rural roads: 70 km/h (for trucks not for coaches).	No.
Slovak Republic	Trucks > 7.5 tons Buses/coaches > 9 seats	Motorways: 110 km/h (instead of 130 km/h).	Yes, EU Directive.
Sweden		80 km/h for trucks. 90 km/h for coaches.	Yes, EU Directive.
Switzerland		80 km/h for trucks. 100 km/h for coaches.	Yes. As from 1 January 2005, all trucks > 3.5 tons.
United Kingdom	> 3.5 tons	60/70* mph on motorways. 50/60* mph on dual carriageways. 40/50* mph other roads. * for buses and coaches and rigid light goods 3.5-7.5 tonnes GVW without trailers.	Yes for trucks, buses and coaches > 7.5 tons.
United States (in 10 states)	> 4-13 tons	5-15 mph lower	No

Table B.5. **Differentiated speed limits for young and novice drivers**

Country	Y/N	Age or experience	Limits	Comment
Canada	Yes – Ontario No – Other jurisdictions	1st year of driving.	Driving on roads with speed limits greater than 80 km/h is forbidden for young and novice drivers.	The prohibition effectively restricts novices from driving on motorways. During the first year of driving, a novice driver must be accompanied by an experienced driver, and is subject to several restrictions, including curfews, 0% BAC, and (in Ontario) roads with speed limits ≤ 80 km/h.
Finland	No Applied until 1996			
France	Yes	Less than 2 years of licence	110 km/h instead of 130 km/h. 100 km/h instead of 110 km/h. 80 km/h instead of 90 km/h.	“A” on the back of the car.

Table B.6. **Recent changes in speed limits**

Country	Date of changes to general speed limits	Road categories concerned	Previous and new speed limits	Reasons that motivated such changes
Australia (Victoria)	2000-2004	All categories.	• Urban default speed limits have been *reduced* from 60 to 50 km/h • School speed limits of 40 km/h • Speed limits through rural town centres *reduced* from 60 to 50 km/h • Speed limits in central business districts of major cities *reduced* from 60 to 50 or 40 km/h • Speed limits through strip shopping centres *reduced* from 60 to time-based 40 km/h	The principal reason is to improve the safety of unprotected road users, *i.e.* pedestrians and cyclists.
Austria	July 1999	Motorways with speed limit 130 km/h	• 70 -> 80km/h for lorries with trailers	Harmonisation in connection with introduction of speed limiters
Canada	Since 1996	Motorways (1 province) Divided main highways (1 province) Undivided main highways (1 province) Urban local and collector streets (1 city)	• Motorways: 100 -> 110 km/h • Divided main highways: 100 -> 110 km/h • Undivided main highways: 90 -> 100 km/h • Urban local and collector streets: 60/50 -> 40 km/h	Need for greater capacity. Public support. Engineering assessment based on 85th percentile speed. School zones, political considerations.
Denmark	30 April 2004	Motorways	• 110 km/h -> 130 km/h locally limits at 110 km/h and 90 km/h	The changes are a consequence of a governmental superior goal to increase the general speed limit on motorways for passenger cars and motorcycles to 130 km/h.
Finland			Not really dramatic changes: • Gradually, lower limits than 50 km/h in urban areas (during 2000-2004), increasing change of 100 km/h to 80 km/h for winter time in main roads (from autumn 2004). • Increased use of 60 km/h (instead of 80 km/h) on rural roads, when dense population nearby.	

Table B.6. (Contd.) **Recent changes in speed limits**

Country	Date of changes to general speed limits	Road categories concerned	Previous and new speed limits	Reasons that motivated such changes
France	No important changes.	Urban roads	• 30 km/h zones have been introduced in some cities.	
Ireland	1 January 2005	All roads	• Motorways: 70 mph (112 km/h) –> 120 km/h • National roads: 60 mph (96 km/h) –> 100 km/h • Non-urban regional and local roads: 60 mph (96 km/h) –> 80 km/h • Built-up areas: 30 mph –> 50 km/h	New speed limit structures expressed in metric values in place of the imperial units of measurement system.
Korea	April 1999	Motorways, main highways	• Motorways : 80 km/h–> 90 km/h • Main highways: 70 km/h –> 80 km/h	Improvement of road condition, request of drivers, deregulation, etc.
Mexico	No recent changes			
The Netherlands	No recent changes			
Norway	2001	Motorways	• Safest motorways: 90 km/h –> 100 km/h	To increase public acceptance of the speed limit system.
Poland	May, 2004	Urban roads	• 60 km/h –> 50 km/h (60km/h from 23:00 to 06:00)	A general perception of the relationship between speed and number of accidents.
United States	Increases in general speed limits: 1996, by 30 states; 1997, by 4 states; 1999, by 1 state (1 state also eliminated unrestricted speeds) 2003 by 1 state for a second time.	Freeways/Motorways, Main Highways, Rural Roads	• rural freeways/ motorways 65 mph -> 70 or 75 mph • urban freeways/motorways 55 mph -> 60 to 75 mph • main rural roads 55 mph -> 60 to 70 mph	Repeal of federal sanctions in December 1995, lack of compliance, unenforceable, lack of public support, State rights.

B.2. Proportion of drivers above the limits (see Tables B.8 to B.12)

This section gives an indication of the level of excessive speed in responding countries. Most of the countries publish an annual speed survey, where the reader will find more detailed information (see Table B.7).

Excessive speed is a common feature in all responding countries. However, large variations can be observed in the extent of excessive speed: it varies from 10% (for instance, United Kingdom, main highways) to more than 80%. The “bulk” of speeding is within +20 km/h above the limit. For a large number of countries, “High” speeding (+20 above the limits) concerns a minority of drivers. Speeding affects the entire road network. Local streets seem to be as much affected as motorways, which is potentially a bigger concern, given the presence of pedestrians, children, etc.

Table B.7. **Annual survey on speeds**

Country	Publication and website
Austria	• Speed surveys are regularly carried out by the Austrian Road Safety Board (Kuratorium für Verkehrssicherheit – KfV). Reports are available in printed format annually (in German).
Denmark	• Speed on Danish roads 1999-2002 http://www.vejdirektoratet.dk/dokument.asp?page=document&objno=78159) • Speed on Danish motorways, after introduction of speed limit 130 km/h on half of the roads http://www.vejdirektoratet.dk/dokument.asp?page=document&objno=78281 • Speed on Danish motorways, monthly figures from 35 areas http://www.vejdirektoratet.dk/dokument.asp?page=document&objno=79460 (.
Finland	• Summary of traffic behaviour factors (in English) http://www.liikenneturva.fi *(The Finnish Road Administration has over 300 automatic continuous traffic measuring points.)*
France	• Speed survey (in French) http://www.securiteroutiere.equipement.gouv.fr/infos-ref/observatoire/conjoncture/index.html
Iceland	www.vegagerdin.is (in Icelandic) Iceland has 26 survey equipments.
Ireland	http://www.nra.ie/PublicationsResources/ListofPublications/RoadSafety/
Netherlands	• Speed measurement http://www.swov.nl/uk/research/kennisbank/inhoud/90_gegevensbronnen/gegevens.htm
Poland	• http://www.krbrd.gov.pl/stan_brd/pasy_bezp_i_predkosc.htm (in Polish)
Sweden	• *Title: Hastigheter och tidluckor 2003 : resultatrapport: Vägverket. Publikation 2004:24*
Switzerland	• *Speed behaviour, 1972-2004* http://www.bfu.ch/english/statistics/2005/05_49e.pdf
United Kingdom	*Vehicle Speeds in Great Britain 2005,* published April 2006 http://www.dft.gov.uk/stellent/groups/dft_transstats/documents/pdf/dft_transstats_pdf_611475.pdf Other statistical information and downloads are available from the Department for Transport website : http://www.dft.gov.uk
United States	Approximately 30 states monitor travel speeds: • 15 States: continuously • 9 States: quarterly • 4 States: semi-annually • 2 States: annually The number of sites monitored by each State varies from 8 to 750, with a median of 40. Six States report speed data on the web: Indiana http://bridge.ecn.purdue.edu/~speed/ Minnesota http://www.dot.state.mn.us/speed/monitorreport.html Nevada http://www.nevadadot.com/reports_pubs/traffic_report/ New Jersey http://www.state.nj.us/transportation/refdata/roadway/speed.shtm South Dakota http://www.sddot.com/pe/data/traf_speed.asp Washington http://www.wsdot.wa.gov/mapsdata/tdo/speedreport.htm

Table B.8. **Proportion of drivers above the limits on motorways (passenger cars)**

Country	Speed limits	Proportion of drivers above speed limits in 2003
Australia (Victoria)		Not applicable in Australia. 85th percentile speeds are recorded)
Austria	• 130 km/h	• 23.2% in 2004
Canada	• 110 km/h • 100 km/h • 90 km/h	• 15 to 53% depending on the provinces • 15-81 % depending on the provinces • 15% (British Columbia)
Denmark *Change in speed limit in May 2004*	• 110 km/h (1999–2002) *April 2005* • 110 km/h • 130 km/h	• 72.4% *April 2005* • 60.2% • 22.5%
France (2004)*	• 130 km/h • 110 km/h	3.1% of drivers 20 km/h above the limit (> 150 km/h) 0.8% of drivers 30 km/h above the limit (> 160 km/h) 9.3% of drivers 20 km/h above the limit (> 130 km/h) 2.6% of drivers 30 km/h above the limit (>140 km/h)
Iceland	90 km/h	80%
Ireland	70 mph until 2005 120 km/h since 2005	23%
Korea	• 100 km/h–110km/h	50%
Netherlands	• 120 km/h • 100 km/h	• approx. 40% • approx.45%
Norway	• 100 km/h	• 56.2% (Hvam)
Portugal	• 120 km/h	• 46% speeding: 30% > 10 km/h 9% > 30 km/h 1% >60 km/h
Russia	• 110 km/h	• 31-41%
Sweden	• 110 km/h (seldom 90 and 70)	• 68,0% (+/- 3,5)
Switzerland	• 120 km/h	• 38%
United Kingdom	• 70 mph	• Cars: 57% >80mph =20%
United States	• 65-75 mph. Varies from state to state: Tennessee: 70 mph Indiana: 65 South Dakota: 75 Minnesota: 70	• 41-66% 55.8% 66.0% 41.3% 56.3%

* In France, a major change occurred in 2003, related to the new automated enforcement campaign.

Table B.9. **Proportion of drivers of passenger cars above the limit on main highways (undivided carriageways)**

Country	Speed limits	Proportion of drivers above speed limits in 2003
Austria (cars in 2004)	• 100 km/h	• 46.8%
Canada	• 100 km/h • 90 km/h • 80 km/h • 70 km/h	• 15 to 76% depending on Provinces • 15 to 74% depending on Provinces • 15 % in British Columbia • 77% in Quebec
Finland	• 100 km/h	• 7.0% > 10 km/h
France (2004)*	• 90 km/h	• 3.6% 20 km/h+ above the limits (> 110 km/h) • 1.3%, 30 km/h+ above limit (> 120 km/h)
Iceland	• 90 km/h	• 62%
Ireland	• 60 mph (in 2003)	• 30%
Korea	• 80 km/h	• 84.6%
Netherlands	• 100 km/h	• Approx. 20%
Norway	• 90 km/h	• 60.1% (Hanekampen)
Poland	• 100 km/h	• 41.6%
Portugal	• 90 km/h	• 65% speeding 44% > 10 km/h 13% >30 km/h 2% > 60 km/h
Sweden	• 110, 90, 70, 50 ,30	• 58,7% (+/- 2,4%), traffic work All State roads
United Kingdom (2005)	• 60 mph	• 10%
United States	• TN: 55 mph • IN: 55 mph • SD: 65 mph	• 65.9% • 76.5% • 52.4%

* In France, a major change occurred in 2003, related to the new automated enforcement campaign.

Table B.10. **Proportion of drivers of passenger cars above the limits on rural roads in 2003**

Country	Speed limits	Proportion of drivers above speed limits
Austria (2004)	• 100 km/h	• 17.9%
Canada	• 80 km/h • 70 km/h	• 15 to 45% depending on the Provinces • 41.3% (Northwest Territory)
Denmark (2002)	• 80 km/h	• 61.4%
Finland	• 80 km/h	• 8.0% > 10 km/h
France (2004)*	• 90 km/h	• 5.2% 20 km/h above the limit (> 110 km/h) • 1.9% 30 km/h above the limit (> 120 km/h)
Iceland	• 90 km/h	• 77%
Ireland	• 60 mph (in 2003)	• 8%
Netherlands	• 80 km/h	• Approx 45%
Poland	• 90 km/h	• 47.6%
Portugal	• 90 km/h	• 55% speeding 34% > 10 km/h 7% >30 km/h 1% > 60 km/h
Russia	• 90 km/h	• 21-56%
Sweden	• 90 km/h	• 58.7% (all state roads)
Switzerland	• 80 km/h	• 24%
United Kingdom	• As Main Highways	As Main Highways
United States	• 55 mph	• 47.1%

* In France, a major change occurred in 2003, related to the new automated enforcement campaign

Table B.11. **Proportion of drivers (passenger cars) above the speed limits on urban roads in 2003**

Country	Speed limits	Proportion of drivers above speed limits
Austria	• 50 km/h • 30 km/h zones	• 50.9% • 77.6%
Canada	• 70 km/h (arterial road) • 50 km/h (local street)	• 15 to 20% • 15 to 40%
Denmark (2002)	• 50 km/h • (local/collector streets)	• 56.4%
France	• 50 km/h • 30 km/h	*Not available*
Ireland	• 40 mph (arterial road) • 30 mph (arterial) • 30 mph (local street) Speed limits as in 2003. Changes occurred in 2005	• 75% • 86% • 36%
Netherlands	• 70 km/h (arterial road) • 50 km/h (arterial road) • 50 km/h (local street)	• Approx. 50% (based on a few sites only) • Approx. 73% • Approx. 45% (based on a few sites only)
Poland	• 50km/h	• 58% (arterial road)
Portugal	• 80 km/h (arterial road)	*Arterial roads:* • 50% speeding 34% > 10 km/h 11% >30 km/h 0% > 60 km/h:0%
	• 50 km/h (collector streets)	*Collector streets* • 70% speeding 47% > 10 km/h 9% > 30 km/h 0% > 60 km/h
	• 50 km/h (local streets)	*Local streets* • 47% speeding 24% > 10 km/h 3% > 30 km/h 0% > 60 km/h
Switzerland	• 50 km/h (arterial roads)	• 21% (arterial roads)
United Kingdom (2005)	• 40 mph arterial roads	• Arterial roads: Cars 26% >45mph=8% Motorcycles 34% >45mph= 17%
	• 30 mph (local streets)	• Local streets Cars 50%; >35mph=22% Motorcycles 49%; >35mph=26% Light Goods vehicles (<3.5T) 52%; >35mph=22%
United States	• 40 mph (arterial roads) • 30 mph (local streets)	• 73.1% on arterial roads • 74.2% on local streets

B.3. Public attitudes towards speed, speed limits and speed control

Table B.12 gives a quick overview of the evolution in public's attitude towards speed and speed control and opinions about the current speed limits. In Europe, the SARTRE project undertook an in-depth study of driver's opinions on the main factors of road accidents, the reader will find in the final report[1] detailed information on this subject.

Overall, there is a positive evolution in population's perception of the danger of excessive speed. As well, there is a better acceptability of speed control measures. Regarding speed limits, most drivers would like to see higher limits, in particular on motorways, while in built-up areas, there is a strong pressure from the most vulnerable road users to have lower speeds.

Table B.12. **Public attitudes towards speed, speed control technologies and current speed limits**

Country	Recent evolution in public's attitude towards speeding and speed control technologies	Opinion about the current speed limits
Australia	• The proportion of the community agreeing that a crash at 70 km/h will be more severe than one at 60 km/h increased from 80% in 1995 to 91% in 2003. • Awareness of the road safety message that you are more likely to be involved in a road crash if you increase your speed by 10 km/h has continued to increase steadily from 55% in 1995 to 70% in 2003. • The view that speeding fines are mainly intended to raise revenue dropped from 58% in 2001 to 54% in 2003. • The proportion who believe it is acceptable to speed as long as you are driving safely fell from 32% in 2002 to 29% in 2003.	
Czech Republic	Most of the population adheres to the concept of traffic calming.	Pressure from car, truck and coach drivers to increase the speed limits. Pressure from pedestrians and cyclists to have lower speed limits.
Denmark	There is a general acceptance of speed limits – especially in urban areas. The problem is the gap between the positive attitudes to speed limits and the actual speed behaviour. "Small" speedings of 10-15 km/h are acceptable for 80 % of the population asked, while "big" speedings (more than 20 km/h) are not acceptable for more than 85 % of the population asked.	Representative public opinion surveys showed that about 60% of the population is in favour of a new higher speed limit on motorways. (Speed limit was already increased in April 2004 from 110 to 130 km/h on 50% of the motorways).
Finland		84 % of private car drivers, 71% of truck drivers and 55% of taxi drivers accept lower limits during wintertime.

1. European Commission (2004). *European Drivers and Road Risk. SARTRE 3 Report.* INRETS, Arcueil, France.

Table B.12. (Contd.) **Public attitudes towards speed, speed control technologies and current speed limits**

Country	Recent evolution in public's attitude towards speeding and speed control technologies	Opinion about the current speed limits
France		74% of the population thinks that current speed limits are justified.
Ireland		All drivers are in favour of an increase in speed limits on motorways. All drivers are in favour of a decrease in speed limits on country roads and roads in built-up areas.
Netherlands	In 1996, 39% of the drivers agreed with the statement that they like to drive fast. In 2002 this percentage decreased significantly to 32% (SARTRE)	50% of the Dutch car drivers are of the opinion that the speed limits on motorways should be higher; 20% think that the limit on main rural roads must be higher; 8% on minor rural roads and 5% on urban roads. A 130 km/h limit for the current 120 km/h sections is a political issue every now and then, but so far unsuccessful. Pressure from residents, cyclists and pedestrian interest groups as well as road safety organisations to reduce speed limits in particular in residential areas and routes from and to schools.
Norway	Population is more and more in favour of on-board device to discourage speeding.	72% of the general public agree that all motorways should have at least a 110 km/h limit (current limits are 90 km/h or 100 km/h). 73% of the general public agree that the speed limit in dwelling areas should be 30 km/h. 40% of the general public think that all urban roads should be limited at 30 km/h).
Portugal		Motorways: according the SARTRE survey 37,7% of drivers (2003) and 47.2% of drivers (2004) think that is safe to increase the speed limit. Positive attitudes towards speed decrease in urban areas.
Sweden	People become more aware of the danger of excessive speeds. More people are in favour of devices such as intelligent speed adaptation.	Pressure from car, truck, coach and commercial drivers to increase speed limits on motorways from: 110 to 120, or 130 km/h. Pressure from pedestrians and cyclists to decrease speed limits from 50 km/ to 30 km/h in urban collector and local streets.

Table B.12. (Contd.) **Public attitudes towards speed, speed control technologies and current speed limits**

Country	Recent evolution in public's attitude towards speeding and speed control technologies	Opinion about the current speed limits
United Kingdom		Some truck driver/operators would like the 40mph limit for trucks over 7.5 tonnes increased to 50mph on rural single carriageway roads. The Government argues against this on safety grounds: trucks already speed, and they are disproportionately involved in collisions with serious or fatal casualties. Some car drivers and motoring organisations want a higher motorway speed limit of 80mph (instead of 70 mph) Again, the government resists on the evidence that this would increase collisions and casualties and increase gaseous emissions and noise. Pressure from cyclists, pedestrians and environmental organisations to decrease speed limits to 20 mph in urban roads and residential roads. Some people argue that 20mph should be applied in all towns, but these limits are currently only applied on residential roads, and not usually on through routes. The government is committed to encouraging local authorities to introduce 20mph zones and also 30 mph limits in villages, to improve safety for everyone, and to improve quality of life and to reduce community severance affecting children and older people. There is also pressure to reduce speed limits on minor rural roads, currently subject to the national 60 mph limit, to 50mph or 40 mph. The Government's new guidance on setting local speed limits, published in August 2006, sets out an approach to single carriageway rural roads based on an assessment of various criteria that include safety, environment, quality of life, economy and mobility. Traffic authorities have been asked to review the speed limits on all their A & B category roads by 2011. .
United States	Approximately 2/3 indicate that automated speed enforcement would be a good idea to identify speeders in school zones, high accident locations, and those going more than 20 mph over the speed limits. However there is probably some social desirability bias in the survey responses, since most communities reject automated enforcement when it is proposed. Since 1997 there has been a decrease in the proportion of drivers who feel that the repeal of the 55 mph speed limit caused driving on interstates to be less safe. Females exhibit the greatest change in perception, with 31% now saying driving is less safe, compared to 37% who felt this way in 1997.	Respondents were more likely to indicate that speed limits should be increased rather than decreased on Interstate freeway (34% vs. 4%) and multilane highways (22% vs. 4%). About equal proportions wanted speed limits increased or decreased on 2-lane rural roads (12% vs. 10%) and neighbourhood/city streets (8% vs. 9%). Also there is political pressure to increase speed limits on freeways. North Dakota recently increased its speed limit to 75 mph on freeways and 70 on main rural roads. Bills have been proposed to increase the speed limit to 75 mph in Kansas and to 80 mph on rural freeways in Arizona. Most complaints about speeding and requests to lower speed limits are in residential areas.

B.4. Enforcement of speed limits: fines, demerit points, licence withdrawal

Table B.13. **Fines and Demerit Points related to excessive speeds (in 2004)**

Country	Amount of speeding	Amount of fines in national currency	Demerit points	Comments
Australia (Victoria)	1 – 9 km/h 10 – 24 km/h 25 – 34 km/h 35 – 44 km/h 45 +km/h	AUS$ 128 (EUR 80) AUS$ 205 (EUR 128) AUS$ 271 (EUR 170) AUS$ 368 (EUR 231) AUS$ 440 (EUR 276)	1 3 4 6 8	Loss of 12 demerit points = loss of licence
Austria	+40km/h in town or + 50 km/h outside built – up areas Up to 40-50 km/h	Variable, 72 to 2,180 Variable, up to 762	No demerit points system	
Canada	 10 20 30 40 50	*Mean (range) of 13 jurisdictions* CDN 82 (15 – 158) [EUR 58 (11 – 112] CDN 122 (30 – 230) [EUR 87 (21 – 163)] CDN 167 (40 – 300) [EUR 119 (28 – 213)] CDN 246 (75 – 560) [EUR 175 (53 – 398)] CDN 343 (75 – 975) [EUR 244 (53 – 693°]	 1 (0 – 3) 2 (0 – 3) 3 (0 – 6) 4 (2 – 6) 4 (2 – 6)	Higher fines in work zones and school zones.
Czech Republic (2006)	• urban areas <=20 km/h, rural areas <=30 km/h • urban areas >20 km/h, rural areas >30 km/h • urban areas >40 km/h, rural areas >50 km/h	CKR 1 500 – 2 500 (EUR 50-90) CKR 2 500 – 5 000 (EUR 90-175) CKR 5 000 – 10 000 (EUR 175-375)	2 3 5	Demerit point system in place since 1st July 2006. Total number of points: 12
Denmark	**% above speed limit** *Passenger cars and motorcycles*: • < 20% • 20 – 29 % *HGV, buses and vehicles with trailers:* • < 30%: *All vehicles on roads other than motorways* • ≥30% fixed surcharge • At speeds ≥ 140 km/h: per 10 km/h excess speed	 • DKK 500 (EUR 67) • DKK 1 000 (EUR 134) • DKK 1 000 (EUR 134) • DKK 500 fines. • + DKK 500 (EUR 67)		A 3 point demerit system has been in force since September 2005. It applies to severe traffic code violations, including speed exceeding the limit by more than 30 %. Such infraction results in one point being recorded on the driving licence. 3 demerit points within 3 years results on conditional loss of licence.

Table B.13. (Contd.) **Fines and Demerit Points related to excessive speeds (in 2004)**

Country	Amount of speeding	Amount of fines in national currency	Demerit points	Comments
Denmark (Contd.)	*All vehicles on motorways with a limit of 100 Km/h or more* • 30-39% At speeds ≥ 140 km/h : per 10 km/h excess speed *All vehicles* > 30%	• DKK 500 (EUR 67) + DKK 500 (EUR 67)	1 point	Motorists who have held their first driving licence for less that three year will have it suspended if they collect 2 demerit points during this period.
Finland	1 – 20 km/h 30 – 40 km/h	Small fixed fine or warning Day-fines, based on salary	No demerit points system	
France	1 – 19 20 – 29 30 – 39 40 – 49 50+ (without recidivism) 50+ (with recidivism within 3 years)	• EUR 68* • EUR 135** • EUR 135** • EUR 135** • EUR 1 500** • EUR 3 750	1 2 3 4 6 6 ***	* Reduced to EUR 45 if paid within 2 weeks. The fine is 135 euros in urban areas where speed limit ≤ 50 km/h (reduced to 90 euros is paid within 2 weeks). ** Reduced to 90 euros if paid within 2 weeks. *** Maximum possible points = 12, for novice drivers = 6.
Greece	• 1 – 20 km/h • 20 – 39 km/h • 40 km/h +, or exceeding a speed of 140 km/h on motorways, 130 km/h on highways, 120 km/h on other roads	• EUR 30 • EUR 60 • EUR 150 +	No demerit points system	
Iceland	*In 90 km/h speed limit:* 21-30 km/h 31-40 km/h 41-50 km/h > 51 km/h	• EUR 410 • EUR 540 • EUR 675 • EUR 810-945	1 2 3 4	And 1 month of driving licence withdrawal And 2-3 months of driving licence withdrawal

Table B.13. (Contd.) **Fines and Demerit Points related to excessive speeds (in 2004)**

Country	Amount of speeding	Amount of fines in national currency	Demerit points	Comments
Ireland	Not specified.	Administrative fines: EUR 80 if paid within 28 days of offence EUR 120 if paid from 29 to 56 days Upon conviction by a court: Up to EUR 800	2 if a fine is paid. 4 if convicted in court.	
Japan		Up to 100 000 (EUR 724)	From 1 to 12	
Korea	• < 20 km/h • 20 – 40 km/h • > 40 km/h	• KRW 30 000 (EUR 24) • KRW 60 000 (EUR 48) (cars) KRW 70 000 (EUR 56) (heavy vehicles) • KRW 90 000 (EUR 71) (cars) KRW 100 000 (EUR 79) (heavy vehicles.)	• 0 • 15 • 30	
Mexico	Not specified	MXN 2,260 (EUR 35) for first violation	No demerit points system	
The Netherlands	 ≤10 km/h 11 – 15 km/h 16 – 20 km/h 21 – 25 km/h 26 – 30 km/h 31 – 35 km/h 36 – 40 km/h >40 km/h on motorways, >30 km/h on other roads >50 km/h	Motorways / Other roads / Road works EUR 30 / 30 / 55 EUR 45 / 45 / 90 EUR 55 / 70 / 115 EUR 90 / 100 / 145 EUR 115 / 125 / 170 EUR 145 / 205 / EIR 170 / 240 / Violation registered * Licence withdrawal	Not yet applicable	* Possibly a summons, dependent on number and size of earlier speed violations.

Table B.13. (Contd.) **Fines and Demerit Points related to excessive speeds (in 2004)**

Country	Amount of speeding	Amount of fines in national currency	Demerit points	Comments
Poland	• ≤ 10 km/h • 6 – 10 km/h • 11 – 20 km/h • 21 – 30 km/h • 31 – 40 km/h • 41 – 50 km/h • > 50 km/h	• ≤≤ 50 PLN (EUR 13) — • 50 – 100 PLN (EUR 13-26) • 100 – 200 PLN (EUR 26-51) • 200 – 300 PLN (EUR 51-77) • 300 – 400 PLN (EUR 77-103) • 400 – 500 PLN (EUR 103-128)	— • 1 • 2 • 4 • 6 • 8 • 10	
Portugal	• ≤ 30 • >30 ≤ 60 • > 60	• EUR 60 - 300 • EUR 120 - 600 • EUR 240 – 1200	No demerit points system	
Russia	• 10 – 20 km/h • 20 – 40 km/h • 40 – 60 km/h • > 60 km/h	• 1/2 minimal salary level (50 roubles – EUR 1.50) or warning • 1 minimal salary level (100 roubles- EUR 3.0) • 1-3 minimal salary level (100-300 roubles – EUR 3-9) • 3-5 minimal salary level (300-500 roubles – EUR 9-15, or withdrawal of licence, depending on court decision	No demerit points system	The minimal salary level used for penalties has been established by the Federal law at 100 roubles (€ 2.90)
Sweden		***Speed Limit*** **≤ 50 km/h** SEK (EUR) / **> 50 km/h** SEK (EUR)	No demerit points system	* re columns 3 and 4: P = Prosecution In the event of prosecution, the fine is based on annual salary and extent of speeding.
	1 – 10 km/h	1 000 (106) / 800 (84)		
	11 – 15 km/h	1 200 (127) / 1 000 (106)		
	16 – 20 km/h	1 400 (148) / 1 200 (127)		
	21 – 25 km/h	1 600 (169) / 1 400 (148)		
	26 – 30 km/h	1 800 (190) / 1 600 (169)		
	31 – 35 km/h	2 000 (211) / 1 800 (190)		
	36 – 40 km/h	2 000 (211) / 2 000 (211)		
	41 – 50 km/h	P* / 2 000 (211		
	51 + km/h	P* / P*		

Table B.13. (Contd.) **Fines and Demerit Points related to excessive speeds (in 2004)**

Country	Amount of speeding	Amount of fines in national currency	Demerit points	Comments
Switzerland	 1 – 5 km/h 6 – 10 km/h 11 – 15 km/h 16 – 20 km/h 21 – 25 km/h	*Urban roads / Rural roads / Motorways:* SF 40 / 40 / 20 – EUR 26 / 26 / 13 SF 120 / 100 / 60 – EUR 77 / 64 / 39 SF 250 / 160 / 120 – EUR 161 / 103 / 77 P* / 240 / 180 – EUR P / 155 116 P / P / 260 – EUR P / P / 168	No demerit points system	Re columns 3 and 4: P = Prosecution.
United Kingdom	Not specified	GBP 60 (EUR 88). Depending on the severity, review in Court. Fine up to GBP 1000 (EUR 1 470) and GBP 2500 (EUR 3 680) if on motorways.	3 If in Court, 3 to 6	
United States *Example: Florida*	*km/h (mph):* 0 – 8 (0-5) 10 – 14 (6-9) 16 – 23 (10-14) 24 – 31 (15 to 19) 32 – 47 (20 to 29) ≥ 48 (≥ 30)	Fines not more than $25-1 000 Maximum Warning USD 25 (EUR 21) USD 100 (EUR 84) USD 125 (EUR 105) USD 150 (EUR 126) USD 250 (EUR 209)	< 24 km/h (15 mph): 3 points > 24 km/h: 4 points Unlawful speed resulting in accident: 6 points Reckless driving: 4 points Highway racing: 3 points	Speeding fines and demerit points vary by State. *See* http://www.nhtsa.dot.gov/people/injury/enforce/speedlaws501/summary_table.htm Double fines in school zones and work zones.

Table B.14. **Suspension or Withdrawal of Driving Licence and Other Penalties**

Country	Amount of speeding, km/h or other criteria (specified)	Duration of suspension or withdrawal	Other penalty	Comments
Australia (Victoria)	25 – 34 km/h 35 – 44 km/h 45 + km/h	1 month 6 months 12 months		
Austria	+40 km/h in town or +50 Km//h outside built-up areas	First time: 2 weeks 2nd time within 2 years: 6 weeks 3rd time within 2 years: 3 months	From the second time onwards, order for training is possible.	
Canada	*Demerit points* 10 – 15 (6, during new driver probationary period)	First suspension: 1 to 3 months Subsequent suspensions: 2 to 6 months		Some jurisdictions impose longer suspension periods for frequent offenders.
Czech Republic	• urban areas <=20 km/h, rural areas <=30 km/h • urban areas >20 km/h, rural areas >30 km/h • urban areas >40 km/h, rural areas >50 km/h	• - • 1 to 6 months • 6 months to 1 year	No.	
Denmark	***% above speed limit*** For cars and light trucks without a trailer: > 60% For HGV, buses, vehicles with trailers and the like: > 40% (> 60% in 30 km/h zones)	*First offence:* Conditional suspension of licence for 3 –5 years. You still have the right to drive. *Subsequent offences:* Withdrawal of licence for 6 months to 10 years or forever. *First offence within 3 years of obtaining first driving licence*: A general prohibition of driving will replace suspension of the driving licence	*First and subsequent offences:* Supervised driving test is required before reinstatement of licence. *First offence within 3 years of obtaining first driving licence:* Special driver training and supervised driving test.	

Table B.14. (Contd.) **Suspension or Withdrawal of Driving Licence and Other Penalties**

Country	Amount of speeding, km/h or other criteria (specified)	Duration of suspension or withdrawal	Other penalty	Comments
Finland	30-40	For repeat offences: withdrawal for up to 6 months. Licence withdrawal after 3 offences during the same year or 4 offences in two years. Novice drivers: withdrawal after 1 offence. Very excessive speeding: withdrawal after 1st offence. Duration of withdrawal: minimum 1 month; depends on severity of speeding.		
France	> 30	Withdrawal of licence up to 3 years	50 km/h with recidivism within 3 years: Up to 3 months imprisonment	Possibility to gain points in case of voluntary training.
Greece	40 +, or exceeding a speed of 140 on motorways, 130 on highways, 120 on other roads	Withdrawal of licence for 1 month		
Iceland	*Demerit points* > 12 within a 3 year period.	Driving licence is withdrawn.		
Ireland	*Demerit points* > 12 within a 3 year period	Licence is withdrawn for 6 months.		
Japan	Not specified.	2 years maximum	Up to 6 months in jail	
Korea	*Demerit Points* > 40 120 200 270	Suspension for 1 year Withdrawal for 1 year Withdrawal for 2 years Withdrawal for 3 years		• Suspension of licence is reckoned from the day a licence is collected on the punishment marks of over 40 points. • Withdrawal of licence: - Base for annulment by exceeding of cumulative demerit
Mexico	• 2nd violation • 3rd violation	• Suspension for 6 months • Definitive cancellation		

Table B.14. (Contd.) **Suspension or Withdrawal of Driving Licence and Other Penalties**

Country	Amount of speeding, km/h or other criteria (specified)	Duration of suspension or withdrawal	Other penalty	Comments
The Netherlands		Depends on number and type of earlier convictions.		There has been discussion about an Educative Measure for Speed Offenders where heavy or repeated speed offenders could be offered a choice between a long period of licence withdrawal or a shorter period after following an educative course on speeding and road safety. This has not led to decisions. An evaluation of such a course for young offenders did not yield unequivocal results. "Brouwer, F. & Heidstra, J. (1998). Educatieve Maatregel Snelheid. Evaluatierapport. Amsterdam: Dienst Verkeerspolitie Amsterdam." (In Dutch).
Poland	*Based on demerit points:* 20 or 24	Not specified.	*Upon withdrawal of licence:* 1. Drivers licensed for less than 1 year, with more than 20 demerit points: training and written and driving test for new DL. 2. Drivers licensed for at least 1 year, with more than 24 points: written and driving test *without* training.	Demerit points are also assessed for non-speeding infractions.
Portugal	> 30 ≤ 60 km/h > 60 km/h	1 month to 1 year 2 months to 2 years	Compulsory training; cooperation on road safety campaigns.	
Russia	> 60 km/h	2-4 months, depending on court decision		
Sweden	> 20 km/h > 20 in a 30 km/h speed limit area > 30 in a 50 km/h speed limit area.	If recidivism within 2 years of speeding: 2 months on average. 2 months to 1 year withdrawal.		Speeding that leads to prosecution normally results in suspension of the driving licence for a certain time period. If licence withdrawal period exceeds 12 months, the driver must pass another test for the driver's licence.

Table B.14. (Contd.) **Suspension or Withdrawal of Driving Licence and Other Penalties**

Country	Amount of speeding, km/h or other criteria (specified)	Duration of suspension or withdrawal	Other penalty	Comments
Switzerland	*Urban roads/ Rural roads/ Motorways* 16-20 / 21-25 / 26-30 km/h 21-25 / 26-30 / 31-35 km/h > 25 / > 35 / > 35 km/h	*After first infraction* Warning Withdrawal of licence for 1 month minimum Withdrawal of licence for 3 months minimum	A corrective driving course (generally of 8 h duration) can be Imposed on drivers who violate traffic regulations and are deemed suitable for training. Other measures, including warnings, withdrawal of licence, or traffic restrictions can also be taken.	After new infractions of a medium or serious nature, the minimum licence withdrawal period is extended in stages. The licence of a driver who commits 3 serious or 4 medium infractions within 10 years will be withdrawn for 2 years minimum. The licence of a driver whose licence was previously withdrawn in that manner and who commits another infraction will be permanently withdrawn.
United Kingdom	*Demerit points* 12 within a 3 year period	Automatic disqualification.	Not specified.	Endorsements for speeding offences must remain on a licence for 4 years from the date of the offence.
United States *Example: Florida*	*Demerit points* 12 in 1 year 18 in 18 months 24 in 2 years	*Maximums* 30 days 3 months 1 year		May attend driver improvement course in lieu of having points assessed.

Citations for speeding (see table B.15)

Fifteen countries provided information on the number of speeding tickets or citations issued in recent years, together with the population of licensed drivers. The resulting rates of speeding citations per year per licensed driver range from 0.019 to 0.610. In other words, the numbers of citations issued were equivalent to 1.9 to 61 percent of licensed drivers (ignoring drivers committing multiple speeding infractions within one year).

Four countries had annual citation rates between 1.9 and 4.1 percent: Greece, Japan, Portugal and Sweden. Four countries reported citation rates greater than 10% per year: Australia, Iceland, Korea and the Netherlands (for car drivers). Only the Netherlands supplied data for driver subgroups: 0.61 for car drivers, and 0.040 for motorcyclists.

Caution concerning interpretation of the data:

The data are indicative of the rates at which speeding citations were issued within reporting countries, but should not be used for comparisons. In particular, the data do not support inferences about the comparative speeding behaviour in different countries, principally because differences in enforcement policy, police enforcement intensity, and levels of automated enforcement will result in significantly different citation rates. Such changes occurring over time make year-to-year comparisons problematical, even within a country, let alone between different countries. Also, the data are for different years.

Table B.15. **Citations for excessive speed**

Country	Road category	Vehicle type	Year	Number of speeding citations (tickets) issued in year	Number of licensed drivers in country, for type of vehicle	Speeding citations per year per licensed driver
Australia (Victoria)	All	All	2003	1 123 881	3 400 000	0.33
Canada	All	All	2001 to 2004	7 of 13 provinces and territories answered this question. National totals are unavailable.	In 2003: 21 436 000	Mean of 7 responses: 0.075 Range:0.029 - 0.164
	All	Commercial vehicles		Not available	961,352	
	All	Motorcycles		Not available	774,362	
Finland	All	All	2003	174 000	3 289 362	0.053
France	All	All	2005	1 639 735 (by the police/ gendarmerie) 4 257 541 (automatic cameras)	~30 000 000	0.16
Greece	All	All	2000	90 122	4 692 925 for all types	0.019
Iceland	All	All	2003	~ 26 000	~ 170 000	0.15
Japan	All	All	2002	2 600 623	76 533 859	0.034
Korea	All	All	2002	9 910 998	21 223 010	0.46
Mexico	Federal roads	Federal public service vehicles	Jan.-Aug. 2004	13 595	328 314 licences for federal public service	0.041
The Netherlands	All	All	2002	~ 7 000 000. In approx. 12% of cases the *driver* is stopped and identified; in other cases the *licence plate holder* is administratively fined.		
	All	Passenger cars	2002	~ 6 000 000	~ 9 800 000	0.61
	All	Commercial vehicles	2002	~ 900 000	Not available	
	All	Motorcycles	2002	~ 50 000	~ 1 300 000	0.04
Norway	All	All	2003	160 500	2 870 651	0.056

Table B.15. (Contd.) **Citations for excessive speed**

Country	Road category	Vehicle type	Year	Number of speeding citations (tickets) issued in year	Number of licensed drivers in country, for type of vehicle	Speeding citations per year per licensed driver
Poland	All	All	2003	821 032	There are at least 10 000 000 new and renewed licences, not including licences issued before 1993.04.30.	On this basis, < 0.082
Portugal	All	All	2003	163,900	~ 4 000 000	0.041
Russia	All	All	2003	360 000 penalties for speeding 60 km/h About 6 000 000 speed limit violations during first half of 2003		
Sweden	All	All	2003	153 000	5 693 000	0.027
	All	Passenger cars			5 675 000	
	All	Commercial vehicles			~ 700 000	
	All	Motorcycles			3 030 000	
Switzerland	All	All		Data available from cantons only.	Data available from cantons only.	—
United Kingdom	All	All	2005	1 786 600 fixed penalties prosecutions 127 100 guilty offences in court Total: 1 913 700	~ 28 000 000 (to be confirmed)	~ 0.058
United States	All	All	2001	13 308 880	191 000 000	0.07

SUGGESTED FURTHER READING

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