Speed Limits

A review of evidence

Elizabeth Box
Edited by David Bayliss
August 2012

RAC Foundation

The Royal Automobile Club Foundation for Motoring is a transport policy and research organisation which explores the economic, mobility, safety and environmental issues relating to roads and their users. The Foundation publishes independent and authoritative research with which it promotes informed debate and advocates policy in the interest of the responsible motorist.

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About the Authors

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A transport planner by training, Elizabeth has an MA in Geography from Trinity College Cambridge, an MSc in Transport planning from Oxford Brookes University and is an elected member of the Chartered Institute of Highways and Transportation. Both the Transport Planning Society and DeHavilland have presented Elizabeth with awards in recent years for her success in the fields of research and campaigning.

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Summary and Conclusions

- Speed limits are an important dimension of road safety management, but driving at speeds in excess of the posted speed limit is common in Britain, although this has been reducing over the last decade. Higher average (but not necessarily maximum) speeds mean shorter journey times, which in turn give economic and social benefits from lower costs and greater accessibility. However, excessive speeding can result in unwanted and costly environmental damage and increased deaths and injuries to motorists and other road users.
- The environmental effects of speeding are principally increased noise and emissions of pollutants and greenhouse gases. The main pollutants are carbon monoxide; hydrocarbons; nitrous oxides; and particulates. The emission rates of these pollutants are highest in slow-moving traffic and are at their lowest between 25 mph and 55 mph. Above 55 mph they rise steadily with increasing speeds, as do CO_2 (carbon dioxide) emissions.
- Noise from road traffic can be a significant nuisance. At speeds up to 25 mph engine noise will usually dominate and this can be made worse with frequent acceleration and braking. Above this speed tyre noise becomes increasingly important.
- Speed is a contributory factor in 27% of deaths from road accidents in Britain, and, with stopping distances trebling between 30 mph and 60 mph, it is estimated that a 5% increase in speed can result in a 10% increase in accidents and a 20% increase in fatalities – depending on the type of road. Similarly the risk of a pedestrian being killed if hit by a car increases from 10% at 30 mph to 70% at 50 mph. A doubling of speed from 30 mph to 60 mph will typically increase noise levels by about 10 dB(a).
- Speeding traffic can also have more subtle effects on the quality of people's lives by making streets, squares and lanes less attractive places and consequently impairing the enjoyment of open space and restricting travel on foot.
- Most drivers speed at some time in their lives and some regularly break speed limits. In uncongested conditions about half of traffic exceeds the speed limits on built-up roads and motorways but this proportion has fallen in recent years. This will have been influenced by changing attitudes to speeding and more effective enforcement of speed limits. Most drivers recognise that speeding contributes to road accidents and that they themselves sometime drive in excess of the speed limit. This is because the posted speed limits are not always seen as appropriate and many drivers make their own judgement about what is a safe speed to drive – and this is frequently higher than the prevailing legal limit by a few miles an hour. Speeding on residential roads is seen as less acceptable than speeding on motorways – especially by men – and generally younger drivers are more likely to speed than older drivers.

- Speeding is sometimes inadvertent as drivers underestimate the speed they are travelling at or do not pay sufficient attention to their speedometer. Cues from within (e.g. noise levels) and outside the vehicle (e.g. peripheral visual signals) can have an influence on this and the absence of these may result in misestimation of speeds. But speeding is often deliberate where a driver feels that he or she can travel above the speed limit safely because traffic is light, because modern cars are safer than those on the roads when speed limits were set or because he or she is very familiar with the section of road in question. Also there are occasions when drivers go faster than they would normally because they are in a hurry, bored, stressed or simply thrill seeking.
- Whilst not the only measure to encourage driving at safe speeds, speed limits are an important means of letting drivers know what is considered to be the safe maximum speed for the type of road they are driving along. Speed limits were first introduced in Britain in 1865 with the emergence of mechanically (steam) powered road locomotives and have evolved to the present regime of national limits of 70 mph on motorways and rural dual carriageways, 60 mph on rural single carriageways and 30 mph on built-up roads: with lower limits on sections of roads determined by local highway authorities. In recent years there have been reviews of how to approach the setting of speed limits with the most recent guidance published by the Department for Transport in 2006.

- The Highways Agency is responsible for speed limits on the strategic road network in England and local highway authorities for other roads. For many years the 85th percentile speed has been the touchstone for setting local speed limits, but this was changed in 2006 to the mean speed – but with some reference to the 85th percentile where this is abnormally higher than the mean. This can be contrasted with approaches in some other countries in which more attention is paid to the balance of costs and benefits of speeds and in particular to Sweden where there is a 'Vision Zero' for road deaths. Variable speed limits (VSLs) are now used on some sections of busy motorways and lower limits are often employed where there are roadworks.
- Recent guidance, however, encourages a more measured approach by local highway authorities to determining appropriate speed limits. A range of factors must be taken into account including accident risk, environmental considerations, the types of road users and severance as well as journey times. In some other countries 'safe systems' approaches are used in determining appropriate limits and computer-based procedures are employed to help in establishing safe limits.
- In setting speed limits it must be recognised that they will not automatically be conformed with and the wider the gap between the posted limit and what drivers judge to be appropriate the lower – all other things being equal – the level of compliance will be. Research has found that, in the absence of other changes, actual speeds will usually change by only about a quarter of the change in the posted limits. However, well-designed accompanying measures and improved levels of enforcement can help close this gap.
- Fixed speed limits necessarily do not reflect variable factors such as the weather, lighting conditions and prevailing traffic conditions, and wider use is made of VSLs in some continental countries. This is clearly a development that deserves careful attention here in Britain, along with such innovations as digital maps of speed limits, which can be used by satellite navigation systems and have the potential to feed into vehicles' automatic speed control systems.
- Motorway and urban speed limits are currently the subject of a good deal of attention, and 20 mph limits on local urban roads both individually and collectively in zones are becoming increasingly common with encouragement from the DfT. Traffic light regimes can be used to regulate the flow and speed of traffic and give priority to pedestrians but need to be designed with care if they are not to encourage non-compliance by drivers.
- Maximum speed limits on motorways on the Continent are generally between 75 mph and 81 mph except in Germany where speeds above 81 mph are allowed on some motorways provided it is safe to drive faster. Here in Britain about half of car drivers exceed the 70 mph limit in free-flowing conditions, and if this excess speeding could be eliminated it has been estimated that 18 fatalities and 64 serious injuries could be avoided each year. Lowering the limit to 60 mph would avoid a further 94 fatalities and 371 serious injuries. There would, however, be costs of ensuring compliance and increased journey times.

- To achieve compliance with speed limits needs an effective enforcement regime, which requires clear information on the prevailing limits, effective detection and appropriate penalties for infringements. An important aspect of this is the tolerance that is given to offending motorists. In Britain a 10% tolerance is normally given for speedometer error plus a 2 mph leeway. Where speeds are detected in excess of this the penalty regime applies and can result in a warning, in attendance at a speed awareness course in the case of minor infringements and in fines plus penalty points for more serious offences.
- Driver education has an important part to play in changing speeding behaviour, although it should not be automatically assumed that on its own it will have very large impacts. As part of a broader regime, however, it can help change behaviour as studies of the effects of speed awareness courses have shown.
- The nature of the road layout and environment can also affect speeding behaviour by creating an awareness of the appropriate speed to drive at. The provision of separate lanes for slower- and faster-moving traffic and roundabouts at grade-level intersections can reduce unsafe speed differentials between potential conflicting vehicle movements. As cyclists are especially vulnerable road users, dedicated cycle lanes can reduce conflicts between fast 'armoured' vehicles and slower soft road users although limits on available space mean these are often difficult to provide.
- The harmful effects of speeding traffic can be particularly marked in residential areas where a combination of lower speed limits (e.g. 20 mph) and street design (e.g. including road humps and chicanes) can keep speeds down to an acceptable level. Reductions in accidents from the introduction of such schemes have averaged 60% with an even higher reduction in fatalities (70%).
- Improvements in automotive technology over recent decades have had a major significance for speeding. Control and performance of vehicles are much improved and this reduces the risk of losing control of vehicles in hazardous circumstances. Also, should there be a crash, the risk of death or serious injury to occupants has been reduced significantly. Whilst cyclists and pedestrians are still vulnerable when struck by a motor vehicle, the design of cars has been improved so that the severity of injury from low-speed impacts has been lowered. Cruise control, intelligent cruise control and speed limiters allow speeds to be regulated by the driver and are capable of being developed further to allow automatically for some aspects of prevailing conditions (e.g. restricting the maximum speed to an externally defined limit).

1. Introduction

The speed at which vehicles travel is a controversial and often discussed topic. Today the UK finds itself in the situation where 48% of vehicles exceed the 30 mph speed limit in free-flowing traffic on built-up roads (DfT, 2010a), a fall from 53% over the past five years. There is both support and opposition for setting and enforcing speed limits.

This short report from the RAC Foundation details some of the existing research on the impact of speed and speed limits, and illustrates some of the more significant issues that the government's forthcoming review of speed limits should address.

2. The Effects of Speed

Traffic speed has significant effects, both positive and negative on the UK's social, economic and environmental conditions. In order to ascertain how and to what extent speed limits should be managed it is important to understand the overall consequences of increasing or reducing the speed of travel.

2.1 The benefits of speed

Speed is often viewed in a negative way, but there are undoubtedly some tangible and positive benefits to increasing the average speed of traffic. For individuals this includes reduced journey times and enhanced mobility and access options. If car journey speeds were increased by 10% then the area that could be accessed by the average journey would increase from 55 square miles to 67 square miles. There are also benefits for the economy with regard to reducing the time associated with transporting goods and with journeys in the course of work. However, journey-time savings are often small, particularly in urban areas where increased running speeds may provide only small savings as a result of delays at intersections and traffic lights. In his study of the long-term links between transport and the UK's economic productivity, growth and stability, Sir Rod Eddington concluded that eliminating existing congestion on the road network would be worth some £7–8 billion of GDP per year (Eddington, 2006).

However, reducing congestion and increasing average speeds is not mainly a matter of increasing speed limits. For example, if a rise in the motorway speed limit to 80 mph increased the average speed of free-flowing traffic from 69 mph to 71 mph this would save around 16 million vehicle hours a year – about a fifth of what is lost from congestion. Therefore average speeds can be best increased by reducing congestion.

2.2 The negative consequences of speed

Speed has significant consequences for the environment and road safety, which need to be addressed and recognised when making decisions about speed limits. The negative impacts of speed are particularly felt in urban areas. Fast-moving motor vehicle are hazardous for pedestrians and cyclists; noise and fumes are a nuisance for both road users and frontagers; and speeding traffic in residential streets can change their character from 'places' to ‘thoroughfares’. On poorly laid-out rural roads excessive speeds increase the frequency and seriousness of crashes.

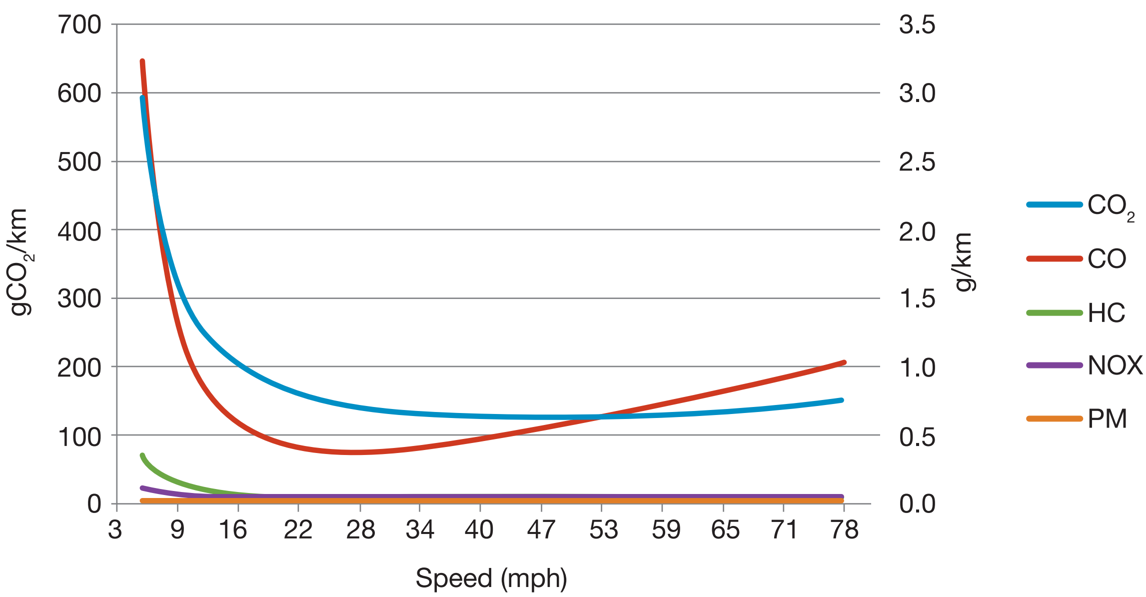
2.3 Environment

Road vehicle emissions contain a variety of pollutants, which differ depending on the speed travelled. The major pollutants are:

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

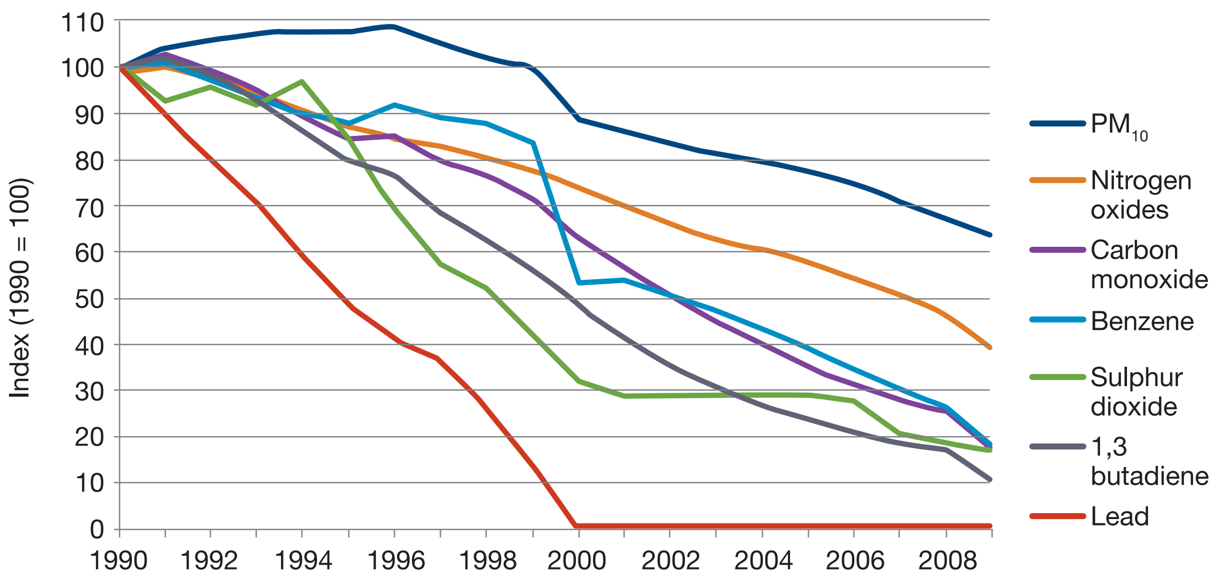
As well as being complex, pollutant production processes vary between different types and vintages of vehicles and are also dependent on the engine technologies deployed. NO_x are at their greatest at high engine operating temperatures, which result from steady high-speed driving. This means that speed-reduction strategies can have quite a significant effect on these emissions, whereas for other pollutants, such as CO and HC, the effect of speed reduction is less clear. Generally speaking, as illustrated in Figure 1, HC emissions reduce with speed, whereas CO and PM ones have the lowest emission profiles at medium speeds. However, these emissions have been steadily falling over the last two decades as shown in Figure 2.

Figure 1: Pollutant emissions as a function of speed



Source: DfT (2009)

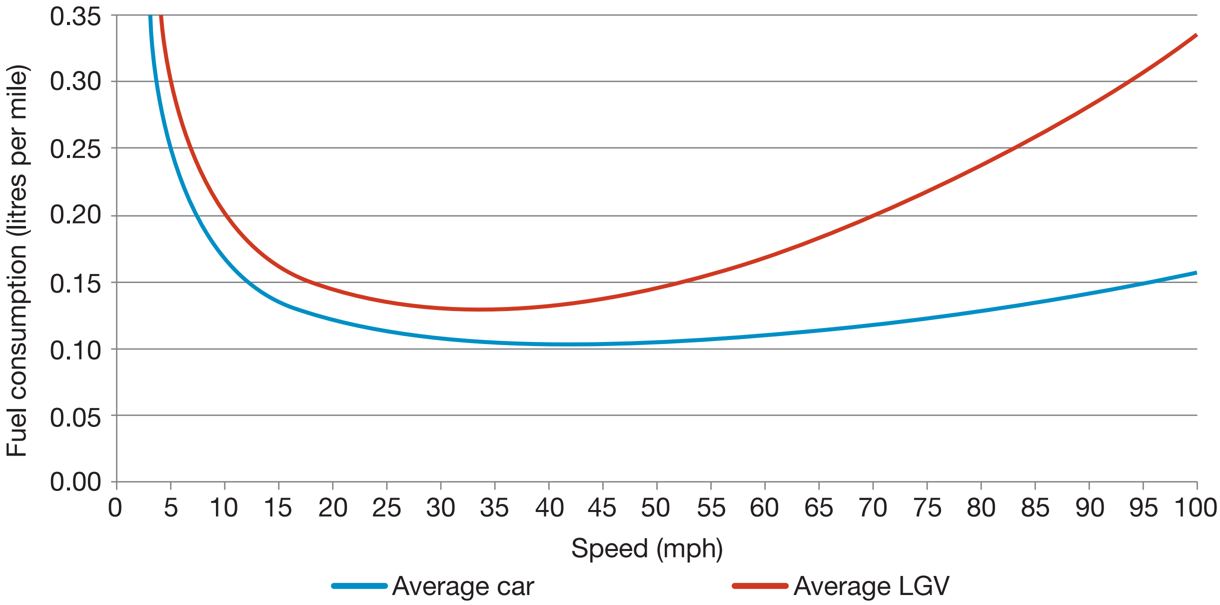
Figure 2: UK air pollutant emissions from transport 1990–2009



Source: DfT (2011e: Table ENV0301b)

Carbon dioxide (CO_2), the most significant greenhouse gas, is generally produced in proportion to fuel consumption. CO_2 emissions also fall steeply as speeds rise to c.20 mph and then change little as speeds increase to 50 mph. Thereafter they start to rise again, although less rapidly than the decline in the <20 mph range. CO and CO_2 emissions are highest at very low travel speeds of around 9 mph or less. In modern vehicles emissions tend to be more sensitive to acceleration than average speeds, meaning that driving style has a significant impact on these overall emissions. It has been estimated that an aggressive driving style can lead to about a 37% increase in fuel consumption (Wengraf, 2012).

Figure 3: The relationship between speed and fuel consumption



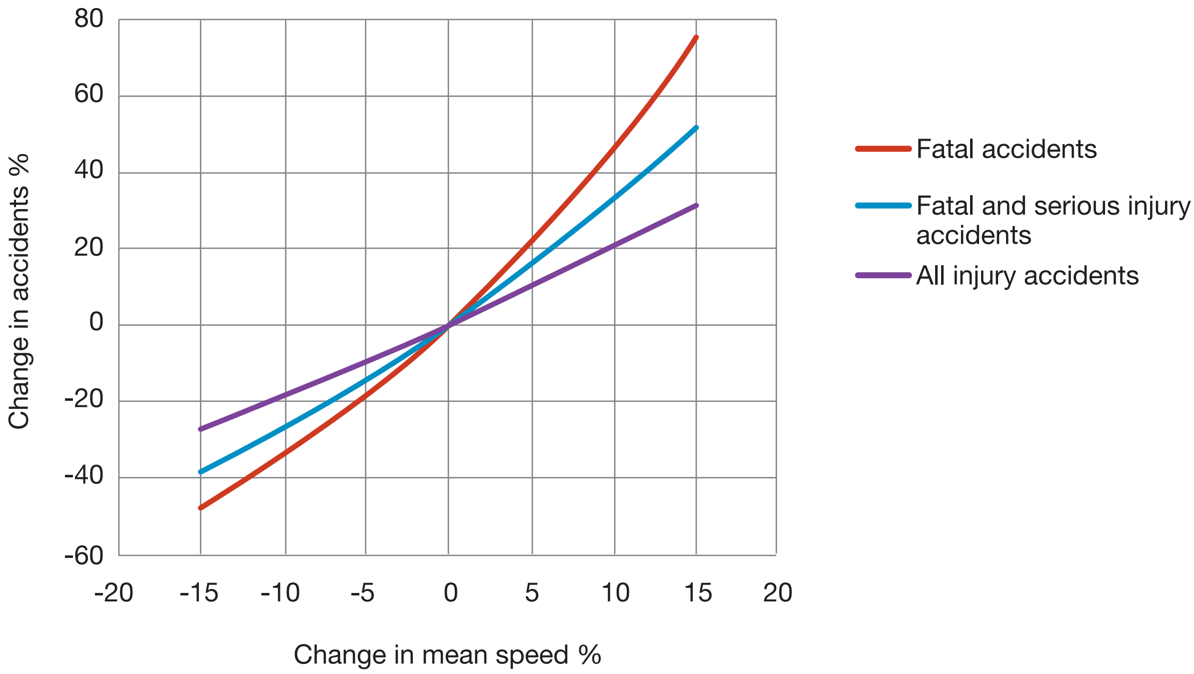
Source: Wengraf (2012)
Note: LGV – light goods vehicle

2.4 Accidents

Speed is noted as a contributory factor in 27% of all road-related deaths in Great Britain (DfT, 2010b). Significant research has been conducted over the years to demonstrate the relationship between speed, accident frequency and severity, and accident reductions. Many researchers have modelled the specific relationship between serious injury accidents, fatal accidents and speed.

One of the most frequently used and well-regarded sources is Nilsson's 'Power Model', which illustrates that a 5% increase in average speed leads to approximately a 10% increase in all injury accidents and a 20% increase in fatal accidents. 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 (OECD/ECMT, 2006). The relative risks of accident involvement from driving faster than the average speed of other traffic have also been found to be very similar to those from increases in the blood alcohol content. This is a general relationship and more recent analysis supports the model but indicates that the powers have been decreasing slightly over time and are lower on urban roads than on rural roads and motorways. The most likely explanation for the slight decrease over time is improvements in car safety.

Figure 4: Nilsson's 'Power Model'



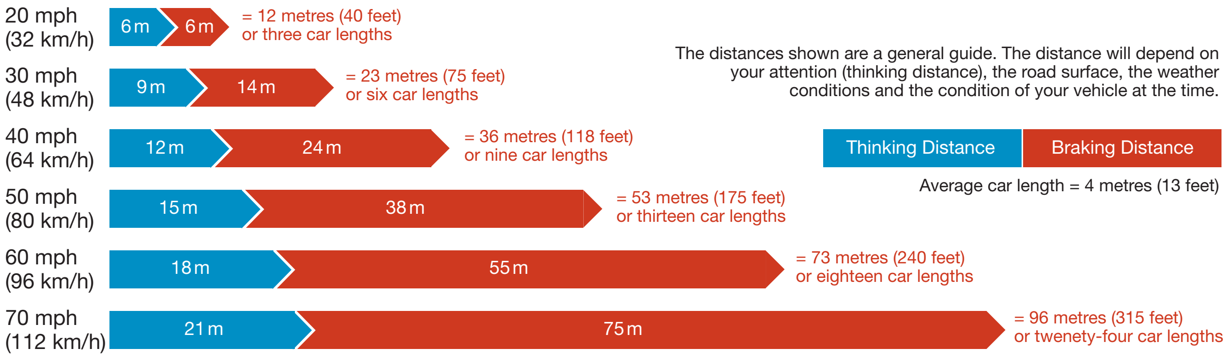
Source: Nilsson (2004)

The design of a road and how it is used affect the precise relationship between speed and accident frequency. Complex traffic environments create specific difficulties for users, which can lead to a higher accident risk; this means that the effect of speed tends to be greater. This issue of complexity goes a long way to explain why motorways experience relatively low accident rates in comparison to urban roads.

Irrespective of whether speed is a direct contributory factor to a collision, the collision severity is highly correlated with the vehicle speed at the moment of impact, due to the higher momentum. On impact the majority of the change in speed will be incurred by any lighter crash 'opponent' – often the vulnerable road user or lighter vehicle. It is for this reason that even minor changes in impact speed can increase the risk of serious injury especially to pedestrians.

Travelling at high speeds also reduces the time people have available to process information and react. The time needed to respond comprises two elements – driver reaction time and braking distance. Driver reaction time, typically one second in standard conditions, is the distance travelled in proportion to the speed and the braking time. Braking distance is proportional to the square of speed (v^2) so the distance between starting to brake and coming to a complete stop greatly increases with speed (see Figure 5). Consequently the possibility of avoiding a collision reduces as speed increases.

Figure 5: Stopping distance at different speeds (including reaction time of around one second)



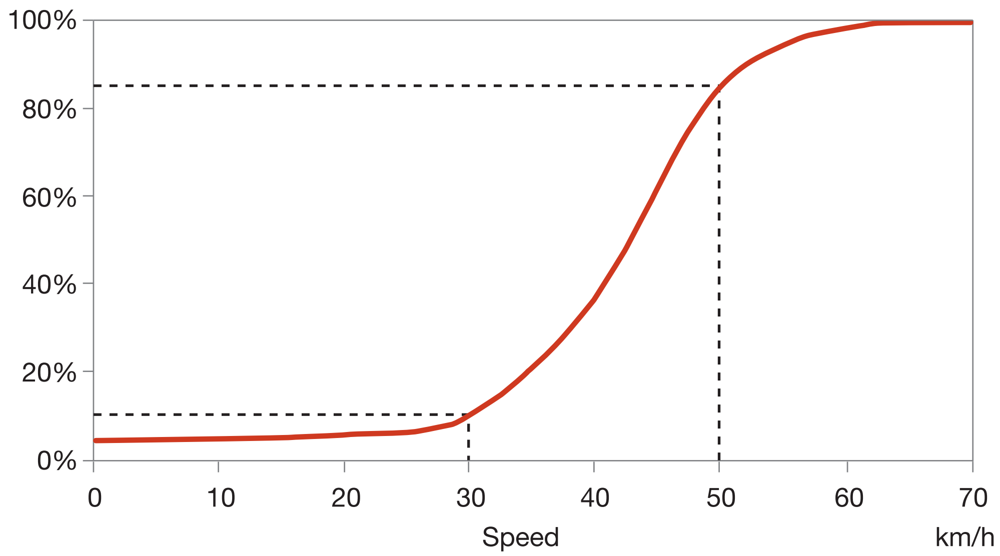
Source: Directgov (2011)

Stopping distances also depend on the condition of the road. They are, for example, much higher on wet than dry surfaces. At 37 mph the stopping distance required on a wet road is more than 25% greater than on a dry road (OECD/ECMT, 2006). Similarly, icy conditions and roads slick from recent precipitation on a greasy patina can dramatically extend stopping distances. Drivers should be aware of this and make appropriate allowances. Whilst stopping on slippery surfaces can be aided by ABS (anti-lock braking system) this will not obviate the need for caution in adverse weather conditions.

The spread of a driver's visual field reduces as speed increases. When travelling at 25 mph a driver has a field of vision covering 100 degrees. At this speed obstacles on the roadside or other potential hazards can be relatively easily seen. At over 80 mph the field of vision covers only around 30 degrees, which significantly reduces the capability of a driver to assess potential dangers (ibid.).

Reducing speeds is important because results from on-the-scene investigations of collisions involving pedestrians and cars show that 98% of pedestrians survive being hit by a car at speeds of 20 mph, whereas only 91% survive at speeds of 30 mph and 60% at 40 mph. By 50 mph survival chances are down to 30%, and at the present motorway speed limit being hit by a road vehicle means that death is almost inevitable (see Figure 6).

Figure 6: Probability of a fatality from being struck by a vehicle

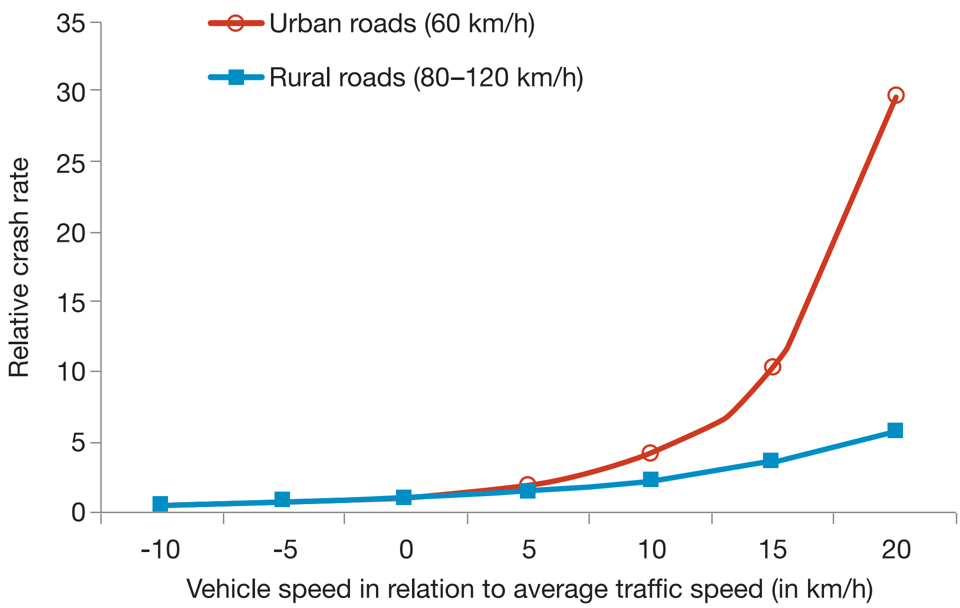


Source: OECD/ECMT (2006)

Throughout Europe speed is found to be a contributory factor in around a third of fatal accidents, and is an aggravating factor in the severity of all accidents. 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 also much more likely to be involved in an accident (OECD/ECMT, 2006). Kloeden et al. (2002) also found a higher accident risk for fast drivers, particularly in urban areas.

Figure 7 indicates that driving at a slower speed than average traffic does not significantly increase risk. However, other studies have found that for non-injury accidents there is similar accident risk for the ‘slowest drivers’ and ‘fastest drivers’. There are potential safety implications associated with other drivers overtaking a slower-than-average driver. Ultimately it is useful to try and reduce the speed differential between vehicles in the traffic stream as this is expected to bring significant accident reductions. Where the speed differential between different road users is very large, such as heavy goods vehicles (HGVs) on the motorway or cyclists on certain roads, it can be appropriate to provide separate or segregated infrastructure. In addition to the increased risk to vulnerable road users there is added risk of serious injury to occupants of light vehicles in collisions with a heavier vehicle (OECD/ECMT, 2006).

Figure 7: Relative injury accident rate on urban roads and rural roads for vehicles going faster and slower than average speed



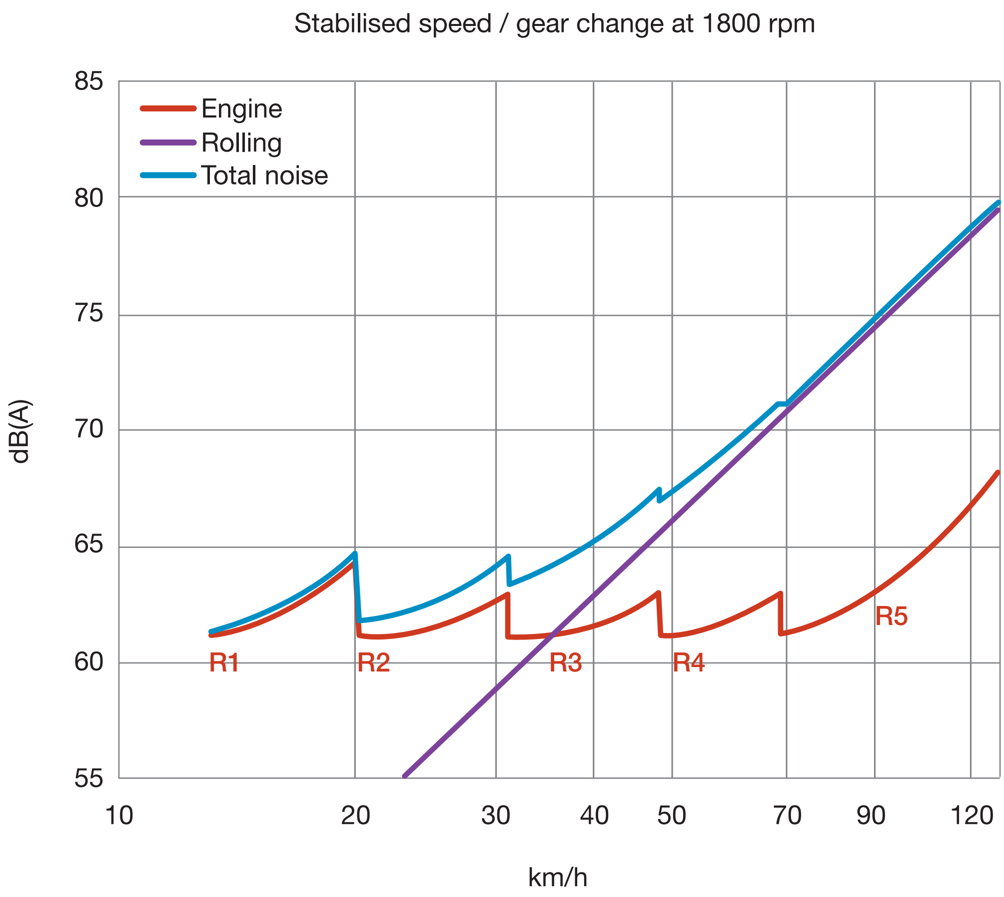
Source: Based on Kloeden et al. (1997, 2001 and 2002)

2.5 Noise

Speed has a significant effect on the noise that a vehicle emits. Driving at lower speeds will generally reduce noise levels, although the frequency of accelerations can be more important than mean speed. Noise is created by the power units on vehicles, tyre-road interaction and air displacement. At higher speeds tyre noise dominates that created by vehicles. Tyre-road noise increases strongly with speed, around 12 dB(A) for a doubling of speed. The effects of acceleration and deceleration on noise are typically modest at speeds over 30 mph, but higher at speeds lower than this. This has implications for the use of chicanes and speed humps at lower speeds, where vehicles are required to accelerate and decelerate.

Figure 8 illustrates the relative contributions of engine and rolling noise to the total noise emitted in relation to speed. As a doubling of noise levels represents a tenfold increase in sound energy both scales are in effect logarithmic. Engine noise dominates up to about 25 mph, when tyre noise becomes more important. At higher speeds tyre and then air displacement noise become the main source of traffic noise. This general picture is of course affected by design features such as the type and condition of road surface and the degree of streamlining of vehicles.

Figure 8: Engine noise and rolling noise as a function of speed



Source: INRETS (2005)

2.6 Quality of life

Traffic speed has been found to affect the assessments people make about quality of life. Although real, this tends to be difficult to quantify particularly as it is those outside the vehicle that tend to be affected. Injuries and noise are effects that are relatively easy to measure, whereas it is much harder to quantify the fear associated with discouraging people from walking and cycling. Physical activity is known to be important in reducing heart disease and strokes (Batty & Lee, 2004), and if the perceived danger from fast-moving traffic dissuades some people from walking and cycling it could affect their health and general fitness. It can also reduce walking to school, which can affect children now and in future. Speeding traffic can also lead to community severance, and this tends to have a disproportional effect on older people and young children.

2.7 Urban sprawl

National or regional changes in speed management policy may permanently change the accessibility of locations in relation to each other. Over time the average travel time budget for individuals has remained fairly static at around one hour a day (DfT, 2011c), which is why an increase in speed can lead to people travelling longer distances as well as making different decisions about home and work locations. Whilst increasing speeds may be of economic benefit through producing wealth as the result of more economic activity, the same process can lead to locational sprawl and its associated disadvantages (OECD/ECMT, 2006). In the long run speed management can affect traffic volumes on the roads, but there is no evidence to suggest that a reduction in speed can help to reverse the process of urban sprawl.

3. The Extent of Speeding

Speeding is something that most drivers admit to doing at some time, and just less than half of cars travelling on the roads in free-flowing traffic exceed the limit. In the ten years from 1999 the percentage of vehicles exceeding the 30 mph speed limit on built-up roads in Great Britain fell for every vehicle type. The most significant decrease was for cars. In 1999, 67% of cars travelled at speeds in excess of the limit; by 2010 this had dropped to less than half (46%) (DfT, 2011e). A Brake survey (Brake, 2004) found that 68% of drivers admitted to driving over the speed limit in the year prior to the survey, and 85% admitted to exceeding speed limits on occasion. As an issue speeding is frequently mentioned by drivers as an activity that they take part in (DfT, 2010c).

On motorways in 2010, 50% of cars exceeded the 70 mph speed limit in free-flowing traffic. In addition, 14% of cars were recorded as travelling at 80 mph or faster. Despite the levels of speeding that appear to take place the majority of drivers and pedestrians consider themselves to be competent and safe road users, with other road users being viewed as more risky and dangerous.

Although speed and speeding are treated differently in various countries, excessive speed is a problem that affects the entire road network across Europe where typically 40–80% of drivers have been found to be driving above the posted speed limits (OECD/ECMT, 2006).

3.1 Public attitudes towards speeding

There is a growing awareness of road safety issues amongst the public and the consequent need to manage speed. Acceptability of speed limits and speed enforcement is higher than it has been in the past (ibid.), and there is also rising pressure both to raise and to lower speed limits in different situations.

A European Commission survey on attitudes to speed found the following (ibid.):

- 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.

A recently published Eurobarometer poll found that 78% of EU citizens claim to be very concerned about excessive speeds (ETSC, 2010b). As in the rest of Europe, speed is thought to be an important issue for improving road user safety in the UK. Key areas that should be addressed, particularly for pedestrians and cyclists, are thought to be fast traffic near schools, in residential areas and villages. Narrow roads with a high speed and a variety of users, often used as 'rat runs', were thought to be especially dangerous in a recent study (DfT, 2010c). In urban areas speed is a particular concern. It may also be that frustration in urban areas can lead to knock-on speeding in rural locations.

In most industrialised countries between 50% and 80% of traffic fatalities typically occur on rural roads (OECD/ECMT, 2006). In rural areas running off the road and colliding with roadside objects are particular problems, which is why many countries have made moves towards removing roadside obstacles. There is some support for adding more signage as well as for having a greater police presence due to the perception that there is a low level of enforcement in rural areas. However, speed limits alone were felt to be ineffective for certain groups of drivers who are perceived to drive too fast regardless of the law (DfT, 2010a). Generally, however, the acceptability of speeding interventions (such as 20 mph zones and traffic calming) increases with appropriate communication and enforcement campaigns (ibid.).

A recent review of the literature on public attitudes to road user safety in Britain (DfT, 2010c) found:

- 90% of the population agree it is important that people drive within the speed limits.
- 39% state it is dangerous to drive over the speed limit.
- The majority continue to 'speed'.
- 76% of drivers completely agree that driving too fast for the conditions is dangerous.
- Speeding beliefs are often informed by the view that speed limits are arbitrary limits and that it is OK to challenge such authority in light of road conditions, experience and competence.
- Drivers tend to define speeding at around 10 mph above the speed limit.
- People driving within their own definition of the 'speeding' threshold still count themselves as 'law abiding' even if they are going above the posted speed limit.
- Drivers tend to think that most people drive on average around 10 mph faster than the speed limit.

- 34–35 mph in a 30 mph zone is seen as acceptable by other drivers.
- 90% of people thought that driving at 40 mph in a 30 mph zone was dangerous.
- 65% thought that driving at 80 mph on a clear motorway was dangerous.
- 60% thought that the 70 mph speed limit was set about right, although 36% felt it should be raised.
- 70% are in favour of stricter enforcement of 30 mph in residential roads.
- 89% support 20 mph zones outside schools.
- 77% support 20 mph speed limits in general on all residential roads.

It is evident that speed management and speed limits form an important part of motorists' experiences. Despite widespread support for speed limits *per se* many motorists prefer their own judgement of what is an appropriate speed to drive rather than the posted limits. Generally, exceeding the speed limit on motorways is regarded as less unacceptable than speeding in residential areas. This review also concluded that there were differences between various types of drivers with men more likely to speed on motorways (but not local roads) than women and younger drivers being more likely to speed than more mature motorists (DfT, 2010c).

3.2 The psychology of speeding

There are a number of reasons why people speed. Social norms often lead to speeding being considered justifiable because many other drivers speed and existing rules of thumb (e.g. thinking authorities will turn a blind eye to speeding, or not enforce it in a certain area) are thought to maintain this behaviour (DfT, 2010a). People also admit to taking deliberate risks, but tend to defend occasional speeding with reasons such as:

- own speed choice felt safe;
- the driver has their own personal experience on the road;
- the speed limits were too stringent or out of date due to modern car technology;
- the roads were empty;
- the journey is thought to be of little risk (e.g. motorway travel);
- being in a rush/time pressure ;
- anger, stress and emotions (particularly connected to congestion and urban driving);
- thrill seeking (particularly younger drivers with a risk-taking personality);
- boredom, particularly on long journeys; and
- lapses in concentration.

People can also find themselves speeding unintentionally, and this is often found to be the case when keeping up with other traffic. People also find that not paying attention to the speedometer can lead to inadvertently travelling over the speed limit (DfT, 2010c).

It has also been found that people's perceptions of other people's speeds are inaccurate. Aberg et al. (1997) found that more than 50% of drivers failed to respect speed limits despite most claiming to be in favour of compliance. Given this finding it is clear that other variables, other than willingness to obey the law, influence the observation of speeds. Drivers who overestimate the speed of other vehicles are also more likely to maintain higher speeds (OECD/ECMT, 2006).

A study by Lerner et al. (2005) found that, as well as teenage drivers in general driving slightly faster than the average population, male drivers tended to drive faster than female drivers and this was significantly influenced by 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 5 mph (OECD/ECMT, 2006).

Distortions in speed estimation have also been attributed to the rate at which drivers accelerate or decelerate. It has been observed that the sharper the deceleration the greater the error in the estimation of speed (Denton, 1967). Managing these transitional situations is said to be difficult for drivers (Saad, 1983), and it has been found that drivers who have travelled a long time on motorways tend to drive faster than other drivers once they have left the motorway (Nouvier, 1987). This is known as the phenomenon of adaptation, which reduces the sensation of speed the longer the driver remains behind the wheel (OECD/ECMT, 2006).

Human factors research indicates that reducing the noise level in vehicles can, in the absence of other limiting factors including traffic and drivers' reference to the speedometer, cause drivers to increase their speeds. Interior noise levels have reduced in recent years as the manufacture and design of vehicles have improved. The increased use of air conditioning, double-glazed side windows (now featured on a few premium car models) and other noise-reduction techniques has gone some way to skew a driver's perception of speed. However, it should also be remembered that these applications have also had a positive impact on road safety, as they help to reduce fatigue and other stress factors associated with driving. How vehicle gearboxes are staged also has an impact on a driver's speed decisions, especially in urban areas, where the staging of gearboxes can make it difficult for vehicles to respect the speed limit with ease (ibid.).

Peripheral and central vision are important components that help a driver establish appropriate speed. Early studies in the 1960s revealed the role played by peripheral vision in estimating driving speeds (Salvatore, 1967). Speeds are estimated more precisely in peripheral vision and underestimated in central vision, which goes some way to explain why drivers underestimate speed on wide roads that lack points of reference (OECD/ECMT, 2006).

4. Speed Limits

Appropriate speed limits are only one element of a speed management approach, but for the foreseeable future they will continue to form the backbone of speed management strategies and policies. Speed limits are used to define acceptable speed and provide a basic indicator to road users of the maximum speed allowed under the law. Speed limits act as an important information source for road users. When set correctly they help reinforce the driver's assessment of a safe speed and act as a pointer to the nature of the road and the risk associated with it.

An effective speed management package is not just about speed limits. It involves infrastructure improvements, appropriate signing and marking, vehicle engineering, education and training, driving-assistance technologies and of course the strategy and methods for enforcement. This paper looks at the value and importance of speed limits as a particular tool for speed management. It is of course not possible to talk about speed limits without some reference to the other measures to make speed limits work, but for the sake of scoping this particular report and answering pertinent policy questions in this area investigations have been limited to speed limits and their enforcement.

4.1 History of speed limits

Speed limits have evolved over time as societies have set different priorities for their road system. In the UK the Locomotives Act 1865 introduced a 4 mph speed limits for motorised vehicles on open roads and 2 mph in towns. These were raised to 14 mph by the Locomotives on Highways Act 1896 (which also abolished the requirement, in the Highways and Locomotives (Amendment) 1878 Act, for mechanical vehicles on public highways to be preceded by a man on foot). The general speed limit was raised to 20 mph by the Motor Car Act 1903, but as cars' performance improved this was widely ignored (Plowden, 1970). After much debate the Road Traffic Act 1930 abolished the speed limit but it was restored at 30 mph on built-up roads in 1935 by the Road Traffic Act 1934. After a trial on motorways started in 1965, the Road Traffic Regulation Act 1967 established the present limits of 70 mph for motorways (reduced to 50 mph between November 1973 and April 1974 to save fuel) (Charlesworth, 1984). The current limits of 70 mph on both motorways and dual carriageways and 60 mph for rural single carriageways were introduced in 1977. The Transport Act 2000 gave local authorities the powers to introduce 20 mph speed limits without the consent of the Secretary of State (SoS) for Transport; below that speed the SoS's consent is required (UK Motorists, 2011).

In 1998 the government's White Paper *A New Deal for Transport – Better for Everyone: The Government's White Paper on the Future of Transport* (DETR, 1998) included a commitment to develop a speed management policy for Great Britain that would take account of the contribution of speeds appropriate to environmental and social objectives, as well as to road safety. This resulted in *New Directions in Speed Management* (DETR, 2000a), a detailed review of speed management policies, which drew upon extensive speed-related research and evidence from the UK and around the world. The review concluded that a national framework was needed for determining speeds on all roads with limits that were rational, consistent, readily understood and appropriate for the circumstances. *New Directions in Speed Management* was published in conjunction with *Tomorrow's Roads – Safer for Everyone*, the government's road safety strategy (DETR, 2000b).

In the Transport Act 2000 the Government undertook to examine the procedures and processes for developing and implementing a possible 'hierarchy' of rural roads for speed management purposes. The conclusion, reported to Parliament in 2001, was that a formal hierarchy of this type throughout the rural community would be costly both financially and in terms of environmental intrusion because of the additional signing that would be required to indicate the different speed limits. Moreover, given the necessary infrastructure and behavioural changes required, the road safety benefits would take too long to realise. The most recent guidance on how speed limits should be set is provided in DfT Circular 01/2006 *Setting Local Speed Limits* (DfT, 2006). This replaces Circular Roads 01/93 (DoT, 1993).

4.2 Responsibilities for setting speed limits

There are a number of agencies involved in the setting of speed limits in Great Britain, where there are three national speed limits. These are:

- a 30 mph speed limit on street-lit roads (sometimes referred to as 'restricted roads');
- a national speed limit of 60 mph on unrestricted single carriageway roads; and
- a national speed limit of 70 mph on dual carriageways and motorways.

In addition to these fixed speed limits variable ones are used on motorways to help smooth traffic flow. Where there are roadworks on major roads the speed limit may be lowered to reduce the risks of accidents and help protect the site workforce.

The Highways Agency is responsible for determining local speed limits on the trunk road and motorway network, and local traffic authorities are responsible for determining speed limits on all other roads. In setting speed limits local authorities work closely with police forces to consider speed limit changes and their enforcement. It is also important that local authorities work with neighbouring authorities to ensure consistency across local authority boundaries. All speed limits other than the national ones are made by speed limit order. Traffic authorities should comply with their own consultation procedures and must as a minimum follow the full consultation procedure, set out in the Local Authorities' Traffic Orders (Procedure) (England and Wales) Regulations 1996, before any new speed limit is introduced. Traffic authorities should consult any local community likely to be affected by the proposals, and where appropriate local community groups representing those likely to be affected, before making the speed limit order.

4.3 Legislative framework for speed limits

Speed limits are the means by which legal sanctions can be brought to bear on those who drive faster than is appropriate for the roads. All speed limits, other than those on restricted roads, should be made by order under s.84 of the Road Traffic Regulation Act 1984. Any speed limits below 30 mph, other than 20 mph limits or 20 mph zones, require individual consent from the SoS. Traffic authorities have a duty to erect and maintain prescribed speed limit signs on their roads in accordance with the SoS's directions. Special authorisation must be sought if traffic authorities wish to deviate from what has been prescribed.

Signing that is contrary to the Regulations must not be installed without first seeking authorisation. Traffic authorities are not permitted to erect different speed limit signs relating to different classes of vehicle. Vehicle-activated signs may be used as an additional measure to warn drivers of a potential hazard or to remind them of the speed limit in force, but they must not be used as an alternative to standard static signing. Street lighting (for the purposes of determining whether or not a road is a restricted road) is not necessarily limited to street lamps, but may extend to lighting provided by authorities or parish councils. Unless an order has been made and the road is signed to the contrary, a 30 mph speed limit applies where there are three or more lamps throwing light on the carriageway and placed no more than 183 m (200 ft) apart. Other relevant legislation includes the Highways Act 1980, in which s.90A–F cover road humps and s.90G–I cover other traffic-calming works. Part VI of the Road Traffic Regulation Act 1984 deals specifically with speed limits, with s.81–84 on different speed limits and the speed-limit order-making process.

4.4 Rationale for setting speed limits

Generally speed limits indicate the maximum speed of travel that is safe for the large majority of road users on the road concerned under good conditions. Speed limits are not intended to be target speeds and drivers should adopt lower speeds if the prevailing conditions mean that travelling at the speed limit is inappropriate. Speed limits should not be set in isolation and should be used alongside other speed-management methods, such as engineering measures, education, training, publicity and enforcement.

The appropriate speed for a section of road takes account of safety, mobility and environmental considerations as well as the impact of the speed on the quality of life for people living alongside the road. The advice provided to local authorities on setting local speed limits is set out in DfT Circular 01/2006 *Setting Local Speed Limits* (DfT, 2006b). This replaces Circular Roads 01/93 (DoT, 1993).

Initially, particularly in continental Europe, speed limits were set to reflect a driver's behaviour using the 85th percentile speed. This approach, first taken in the 1960s, was based on the premise that drivers make rational choices and only those in the minority (in this case the fastest 15%) would be judged as speeding. The understanding of speed-related crashes has increased since this time as limits are now regularly set to take account of road design factors (e.g. sight distance and road curvature). Economic trade-offs have also been introduced through cost–benefit analysis, and Sweden has introduced a 'Vision Zero', which makes avoiding death and injury an absolute priority (ETSC, 2010b). When setting speed limits on local roads, local authorities in Great Britain are required to consider the mean speed whilst still noting the 85th percentile figures for individual roads.

Sweden – Vision Zero

Vision Zero as developed in Sweden focuses on human impacts to determine speed limits on the road network. With the finding that pedestrians and other vulnerable road users may well not survive if hit by a car going faster than 30 km/h (19 mph), this lead to the conclusion that roads where there was a mixture of pedestrians and cars should not have a speed limit higher than 30 km/h. In a modern car it has also been established that a car occupant will not be able to survive a side impact of more than 50 km/h (31 mph). This leads to the conclusion that speed limits at intersections, where side impacts are a risk, should not exceed 50 km/h. Car occupants are also not expected to survive a frontal collision in modern cars at speeds higher than 70 km/h (44 mph) so if higher speeds are required median barriers should be introduced.

Ultimately local authorities can set local speed limits in situations where it is deemed appropriate for drivers to be limited to a speed other than the national speed limit. Speed limits should be evidence-led, self-explaining and should seek to reinforce people's assessment of a safe travelling speed. When setting limits local authorities are encouraged to settle on a level that will encourage self-compliance. In 2006 when the guidance was published local authorities were asked to review the speed limits on all of their A and B roads by 2011 in accordance with the guidance suggestions. The guidance stressed the fundamental role of speed limits in meeting governmental objectives around balancing the need to travel with the requirement to improve quality of life, tackle social exclusion and improve the environment of rural communities.

The underlying principles for setting speeds were given in the DfT Circular 01/2006 (DfT, 2006b) as follows:

- Alternative speed management options should always be considered before a new speed limit is introduced.
- The underlying aim should be to achieve a 'safe'[1] distribution of speeds, which reflects the function of the road and the impacts on the local community. The needs of vulnerable road users must be fully taken into account.
- Traffic authorities will wish to satisfy themselves that the benefits exceed the disbenefits before introducing or changing a local speed limit.
- Local speed limits are determined using a series of underlying principles.
- What the road looks like to road users should be a key factor when setting a speed limit.
- Mean speeds should be used as the basis for determining local speed limits. These are underpinned by extensive research demonstrating the well-proven relationship between speed and accident frequency and

1 A mean speed appropriate to the prevailing conditions, and all vehicles moving as close to the posted speed limit as possible.

severity, and also reflect what the majority of drivers perceive as an appropriate speed to be driven for the road. This is a change from 85th percentile speeds suggested in the Circular Roads 01/93 (DoT, 1993). It is suggested that the relationship between mean and 85th percentile speeds is constant, and that there is a need to try and align these where possible.

- The minimum length of a speed limit should generally be not less than 600 m (2,000 ft) to avoid too many changes of speed limit along the route.
- Speed limits should not be used to attempt to solve the problem of isolated hazards (such as a single road junction) or reduced forward visibility (such as a bend).

The guidance stated how an analysis of the current situation can indicate the need to change speed limits (DfT, 2006b: 9):

> "A study of types of accidents, their severity, causes and frequency, together with a survey of traffic speeds, should indicate whether an existing speed limit is appropriate for the type of road and mix of use by different groups of road users, or whether it needs to be changed. Concerns may also have been expressed by the local community. It may well be that a speed limit need not be changed if the accident rate can be improved or wider quality of life objectives achieved by other speed management measures. These alternative options should always be considered before proceeding with a new speed limit."

Before setting speed limits local authorities are encouraged to review the costs and benefits of the change. This should in particular look at:

- accident and casualty savings;
- traffic flow and emissions;
- journey times for motorised traffic;
- journey-time reliability;
- the environmental impact;
- the level of public anxiety;
- the level of severance by fast-moving traffic;
- conditions and facilities for vulnerable road users;
- the cost of associated engineering or other physical measures and their maintenance;
- the cost and visual impact of signing and possible environmental impact of engineering or other physical measures; and
- the cost of enforcement.

Trade-offs undoubtedly have to be made when setting speed limits, but in much of Europe it is considered unacceptable for the aggregation of thousands of very small trip time savings to offset actual human impact and accident trauma. In this type of environment time savings are considered non-transferable, and the OECD/ECMT (2006) reported that such trade-offs have long been considered unacceptable in, for example, workplace safety practice.

One approach that has been used for setting speed limits for several decades is to take the prevailing speed of traffic as a starting point and then make appropriate modifications. However, the national speed limits of 30 mph on urban roads, 60 mph on rural single carriageway roads and 70 mph on motorways were determined at the national level, and do not necessarily fully reflect this approach. The speed below which 85% of drivers in free-flow traffic conditions travel has historically been used as the first step towards developing a maximum reasonable and safe speed. This idea was used when implementing early speed limits on the basis that a large majority of drivers would be travelling at an appropriate speed. This approach is now generally considered to be no longer relevant because the effect of increasing the limit by a few mph has been determined.

A ‘safe systems’ approach to setting speed limits is now widely advocated, although a number of countries including Great Britain continue to base their speed limit setting on the mean speed. This approach is thought to create a better balance between the speed at which the majority of drivers travel and the needs of other road users or local communities. However, speed limits can quickly become discredited as this approach is not based on a risk assessment and it assumes that drivers have good knowledge of risk at selected travel speeds, which is not necessarily the case. In some parts of continental Europe the starting point for setting speed limits is the threshold of physical resistance of the human body to the changes in speed occurring during a crash. From a safety perspective, the threshold of physical resistance of the human body to the force imposed on it during an accident (which is related to the impact speed and the masses of the colliding vehicles) is a critical input to the assessment of appropriate speed. This input has to be put alongside the character of the road, including its physical layout and the other users and activities it serves, as well as recognising the way drivers and their vehicles can be expected to behave under the prevailing conditions.

When setting urban speed limits traffic authorities are encouraged to adopt the Institution of Highways and Transportation's (IHT) *Urban Safety Management* guidelines (IHT, 1998), in which road hierarchies are adopted that reflect a road's function and the mix of traffic that it carries:

- The national speed limit in urban areas is 30 mph.
- The Department encourages and supports 20 mph limits and zones in situations where there is a particular risk to vulnerable road users.
- Roads suitable for a 40 mph limit are generally higher-quality suburban roads or those on the outskirts of urban areas where there is little development.
- In exceptional circumstances 50 mph limits can be implemented on special roads and dual carriageways, radial routes or bypasses where the road environment and characteristics allow this to be done safely.

Across the European Union it is advised that in urban areas speed limits should not exceed 50 km/h (31 mph), with 30 km/h (19 mph) zones promoted in areas where vulnerable road users (including children) are particularly at risk. If hit at 50 km/h there is a 70% chance that a pedestrian would die. If the impact speed is reduced to 30 km/h the chance of death is reduced to 10% (see Figure 6). 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 (OECD/ECMT, 2006).

Consistency between similar road types is important in assisting drivers with understanding the requirements of the road network and developing appropriate driving habits.

In the UK and elsewhere speed limits have come under criticism for not being scientifically based. A significant proportion of the public routinely breaks the speed limit, which suggests they do not perceive the limit to be set at the limit appropriate for them. A credible limit has been defined as a limit that matches the image that is evoked by the road and the traffic situation (van Schagen et al., 2004).

Where limits are deemed by most drivers to be not credible, drivers are more likely to choose their own speed. If speed limits that are not perceived as credible are encountered regularly the whole speed limit system is potentially undermined. Ultimately when there has been a change in the road layout or speed limit the reason for this should be fully communicated. Physical features that influence motorists on the credibility of speed limits include the presence or absence of a bend, the clarity of the situation, the view ahead and the view to the right. It is important that the speed limit is not too high or low given the design speed of the road, otherwise this will undermine its effectiveness. If a local area requires a lower speed limit because of the mix of users on the road, it is clear that along with a speed limit reduction alterations should also be made to the road environment to improve the limit's credibility amongst drivers and make the safe driving speed intuitive. There is also a need for a degree of consistency between speed limits and road environments so that the public can start to become accustomed to particular speed limits associated with different road environments.

In a number of countries models have been used to assess the most appropriate speed limits, from a road safety point of view, based on a variety of factors. The most widespread model used is the LIMITS programme (OECD/ECMT, 2006). This programme is a computer-based one for assessing speed limits. It consists of a number of decision trees 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 and the quality of life.

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; and
- speed limit on adjacent sections.

Whilst systems such as LIMITS aid greater consistency and reduce subjectivity in setting speed limits they do not take all relevant factors into account. Consequently they provide a useful starting point for determining appropriate speed limits, but they should be accompanied by more detailed risk assessments to ensure that all the material considerations are weighed in the final decision.

4.5 Observance of speed limits

If speed limits are put in place or changed without supporting road infrastructure, education or enforcement activity, they have only a limited impact on speeds. According to the OECD/ECMT (2006) meta-analysis, reducing the limit by 10 km/h (6 mph) decreases speeds by 3–4 km/h (2 mph). In places where speed limits have changed and no other action is taken, the change in average speed is about 25% of the change of the speed limit (ETSC, 2010b).

Studies that have examined the contribution of speed limits to speeding behaviour have shown that drivers do not usually comply strictly with speed limits (OECD/ECMT, 2006). The extent of speeding tends to vary based on the perceived reasonableness of the speed limit, the driving context and the driver's own characteristics. The perceived speed of other road users also has an influence, as does the driver's perception of the utility (e.g. reduced travel time, thrill seeking) and disutility of non-compliance (e.g. penalties, likelihood of getting caught, fuel consumption, accident risk). Some may believe they are safe drivers at high speeds, so it is the probability of detection that is likely to have the greatest impact on this group. Posted speed limits can be described as one influence on speed choice, but social norms are extremely important. The importance of social norms has been investigated by the likes of Biecheler and Peytavin (1997), who found that 'social conformity' has an important role to play in average road speeds.

4.6 Developments in speed limits

How speed limits are being implemented and used are changing, particularly with technological innovations. Great Britain currently makes only limited use of variable speed limits (VSLs), apart from targeted sections of the strategic highway network. There they are an integral component of 'managed motorways', which includes hard-shoulder running schemes and the enforcement of speeds at roadworks. In some other European countries national and local governments allow for VSLs, whereby the limit changes according to time of day (daytime/night-time) and time of year (summer/winter). These variations are sometimes introduced on a temporary basis to address issues such as air quality or elevated levels of pollution because of high temperatures. A further step would be to introduce VSLs that take account of actual traffic and weather conditions.

It is important that Great Britain starts to look further at the possibilities in this area. So far the introduction of VSLs outside of the non-motorway network has been hampered by the high cost of the required infrastructure. In Sweden a fiveyear trial of VSL signs was conducted between 2003 and 2007. The trial involved 20 test sites, located in different parts of the country. It included four main types of applications: intersections including bus stops: stretches of road with vulnerable road users: links with dense traffic; and links with adverse road conditions. Some important conclusions emerged from the evaluation activities. VSLs at intersections resulted in speed reductions of 5–15 km/h (3–9 mph). Weather-controlled VSLs also gave extra encouragement to reduce the speed under difficult road conditions and traffic-controlled VSLs created a smoother flow and less sudden braking (Lindkvist, 2009).

Some continental European countries are now mandating that nationwide digital speed road maps are prepared to build up an accurate and continually updated picture of speed limits. Sweden and Finland in particular have taken forward this approach, and a European project about the exchange of road safety attributes has found that speed limits are the most frequently changing attribute, with 7–9% of speed limits changing within a year on the road networks examined within this project (ETSC, 2010a). These electronic maps can be used immediately by in-car navigation systems and may eventually be included in any new technologies such as Intelligent Speed Adaptation. The EU's Intelligent Transport Systems Action Plan and Directive will help foster the standardisation of digital speed mapping throughout Europe (European Commission, 2012).

The UK Government has recently committed to commencing an examination of speed limits and has in particular posed specific questions about the speed limits on the urban and strategic network. The following section reviews some of the evidence on these and other speed limit initiatives. This does not include single carriageway rural roads, where a high proportion of serious accidents take place.

4.7 Urban speed limits

Many traffic authorities are now implementing 20 mph zones and 20 mph speed limits, and this is encouraged and supported by the DfT. Since July 1999, the Road Traffic Regulation Act (Amendment) Order 1999 has given traffic authorities the powers to introduce both 20 mph speed limits and 20 mph zones without obtaining the consent of the SoS. Details of the relevant amendments to legislation can be found in Circular Roads 05/99 (DETR, 1999a). Traffic Advisory Leaflet 09/99 (DETR, 1999c) gives advice on how and where to implement 20 mph speed limits and 20 mph zones. It states that:

- they should not be implemented on roads with a strategic function or on main traffic routes;
- successful 20 mph zones and 20 mph speed limits should be generally self-enforcing;
- traffic authorities should take account of the level of police enforcement required before installing either of these measures; and
- 20 mph speed limits are unlikely to be complied with on roads where vehicle speeds are substantially higher than this, and unless such limits are accompanied by the introduction of traffic-calming measures police forces may find it difficult to routinely enforce the 20 mph limit. Traffic authorities should therefore always consult the local police force when considering possible 20 mph limits or zones, and thereafter as part of the formal consultation process.

4.8 Motorway speed limits

Despite their higher speeds motorways are generally the safest roads across all networks, and this is generally due to their higher design standards and the absence of pedestrians, cyclists and slow-moving vehicles. Most European countries' interurban motorways have a speed limit of 75–81 mph, and whilst there is no legally enforced limit on one third of Germany's motorway network the recommended top speed is 81 mph. If involved in an accident a driver on the German motorway network is held responsible if they are travelling more than 81 mph. The speed limits on European motorways range from 56 mph (Norway) to 93 mph (Italy). The average speed limit for all countries across Europe is just under 76 mph. The most frequently occurring speed limit is 81 mph (ETSC, 2010b).

Some 50% of the driving population currently exceeds the 70 mph limit in free-flowing traffic on UK motorways. If this limit were more strictly enforced by average speed camera detection the following effects have been estimated (Sexton & Johnson, 2009):

- 37 fewer lives would be lost per year on the motorway.
- There would be a decrease of 138 serious and 817 slight casualties.
- There would be an emissions reduction of 2.9% CO_2 and 4.0% NO_x.
- Journey times would increase by 3 minutes in every hour (5%).

It was assumed in the above estimation that all drivers currently exceeding the speed limit travel at 70mph and all other drivers' speeds are unchanged. The same calculation has been done for raising the current 70 mph limit to 80 mph with the higher limit enforced by average speed camera detection. It has been found that this would have the following effect (ibid.):

- 18 extra lives would be lost (full-year estimate).
- There would be an increase in 64 serious and 363 slight casualties.
- There would be an emissions increase of 1.7% CO_2 and 1.8% NO_x.
- Journey times would decrease by 4.1 minutes every hour.

If the current 70 mph limit were lowered to 60 mph with the lower limit enforced by average speed camera detection the following effect is anticipated:

- 94 fewer lives lost per year on the motorway.
- There would be a decrease of 371 serious and 2,376 slight casualties.
- Emissions reduction of 7.3% CO_2 and 10% NO_x.
- Journey times would increase by 6.8 minutes in every hour.

The net present value of this approach is negative due to the large offset for the increase in travel time. Similar assumptions were made to those used for the stricter enforcement of the 70 mph limit, and it is important to recognise the greater the departure from the current speed limit/enforcement regime the less reliable these estimates become.

Decisions on speed limits essentially come down to a policy decision on weighing up the costs and benefits. If the government were to take a Sweden-style 'Vision Zero' approach it is unlikely that they would increase the speed limit to 80 mph.

5. Traditional Traffic Management Measures and Speed Control

It is possible to use traditional traffic management measures as a form of speed control. 'Green waves' is a term used to describe the strategy of regulating traffic flow by means of traffic lights. This approach is used to minimise journey time and stops on major routes by adjusting three parameters: cycle time, green times and coordination speed. Using this approach it is possible to reduce the speed of drivers, who will see one or two green lights ahead, but the lights are timed so that they do not gain by driving faster than the coordination speed. This approach can be very helpful at moderating speeds at times where speeds can be high, such as during the night.

The first successful application of green waves in Britain was on the A40 in West London before the Second World War. Experimental programmes with green waves carried out in French towns are also showing promising results. 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 10–20% in average speeds, and 15–25% in the speed exceeded by 15% of vehicles (85^{th} percentile speed) (Chauvin et al., 1999). However, some towns have also applied the same principle at peak times, without having observed any serious malfunctions.

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, a vehicle approaching too fast may 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. 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; or
- by extending the ‘clearance red’, which delays the green for the other vehicles for their protection.

6. Enforcement

Traditional police enforcement and automated speed control are needed to complement the setting of speed limits. Setting the right tolerance level for the enforcement of speed limits is also important. If the tolerance level is too high this can send out the wrong message to motorists and undermine the system. It has been suggested that tolerance levels for exceeding speed limits should have a minimum (e.g. 5%) to allow for possible inaccuracies of the measurement device and speedometers (OECD/ECMT, 2006). In the UK, the Association of Chief Police Officers (ACPO) currently advises an enforcement tolerance level of around 10% plus a margin of 2 mph.

It has been suggested that the randomness of enforcement is a major determinant of a driver's subjective assessment of risk, and so this needs to be taken into consideration when conducting an appropriate enforcement campaign (OECD/ECMT, 2006). An 'anywhere anytime' enforcement programme could therefore 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 that has a safety impact not only at the location of the cameras but also at a network level. It is vitally important that any implementation of automatic enforcement includes adequate provision of information to the media, interests groups and the public. Whether and how the fines are reinvested also has an important bearing on acceptance of such initiatives.

There is much public debate about the legitimacy of receiving penalty points and charges for travelling just a few mph over the speed limit, but research evidence indicates that enforcing these so-called 'minor' infringements is actually very important. The SWOV (the Dutch Institute for Road Safety Research) has calculated that 5–10 deaths and 200–300 injuries could be prevented annually in the Netherlands if small and often unintended speeding offences were eradicated (SWOV, 2010). Such speeding offences are defined by the Ministry as offences of 10–15 km/h (6–9 mph) above the legal 30 km/h (19 mph) or 50 km/h (31 mph) speed limit.

7. Education

Education aimed at increasing knowledge and changing attitudes is a vital component to achieving appropriate and well-adhered-to speed limits, although on its own the effectiveness of education may be limited as McKenna (2010) concluded:

> "A consistent complaint is the proliferation of interventions that are based neither on theory nor on a formal body of work, and with no supporting evidence. The burden of proof has shifted. In the past it would appear that the assumption has been that educational interventions are effective. Now educational interventions must demonstrate their effectiveness."

Speed limits should therefore not be changed or introduced without adequate education and training about why the change has been made. The logical basis of the system needs to be explained and the production and dissemination of information should be a continuous activity.

An investigation into the effects of speed awareness courses in 2006 (Fylan et al., 2006) showed that the rates of reoffending for course participants was significantly lower than those for similar but not identical groups. This suggests that this form of 'education' can play a valuable part in regimes to reduce excessive speeding.

8. Road Infrastructure

Road infrastructure developments and changes are important for reinforcing speed limits. How the road looks should support the speed by being 'self-explaining', and road improvements should be designed in such a way that if an accident does occur the network is 'forgiving'. However, ultimately, when it is not possible to upgrade the infrastructure at reasonable cost to the standard required for a set speed limit, the appropriate action should be to lower the speed limit accordingly.

When vehicles of different masses travel at varying speed on the road network this can create high-risk stretches of road. To overcome this mismatch transport policies in several countries require separate lanes, whether on the motorway or rural roads, solely for slow-moving farm or freight traffic. It has also been found that roundabouts are an effective injury reduction measure, because vehicles are merging, diverging or travelling in the same direction and the angle of any impact is less than 90 degrees. In their meta-analysis, Elvik and Vaa (2004) reported 10–40% fewer injuries from accidents, the reduction depending on the number of arms on the roundabout and on the previous form of traffic control. The largest reduction was at four-arm junctions with prior traffic signals, where there was a higher reduction in fatal and serious accidents than for slight injury accidents, but there was an increase in damage-only collisions at roundabouts. Where they provide adequate capacity, roundabouts with an outer diameter of 30–50 m (100–165 ft), with one lane on the circle as well as on the entries and exits, contribute to increased road safety, both in terms of efficiency on road safety as well as on the desired change of the speed.

Cyclists are a particularly vulnerable group in this regard, which is why moves have been made to provide dedicated cycle tracks on- and off-road. Unfortunately, space is often a limiting factor. In the Netherlands, for example, cycle lanes are mainly used on 30 mph urban roads and 37 mph rural roads. Such 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 37 mph and 50 mph roads of this type with non-compulsory bicycle lanes showed a slight decrease (a few km/h) in average speed (Kooi & Dijkstra, 2003).

Road infrastructure measures are also needed in transition zones as drivers tend to underestimate their speed and do not reduce their speed enough to comply with lower speed limits. In villages, 'gateways' as well as road narrowing have been introduced to lower speed. Built-up areas have in many areas been transformed through the redesign of urban streets and spaces to reduce through traffic and provide a more suitable environment for vulnerable road users. Lower speeds are important for perceived or actual safety in these types of areas, and there are many road infrastructure measures, such as ‘at grade’ intersections, that can be used to maintain lower speeds. If done consistently across a number of areas infrastructure measures can help drivers to recognise how the traffic environment corresponds with the posted speed limit.

Homezone and slow-speed areas are initiatives based on the ‘woonerf’ (i.e. ‘living streets’) concept, which encourages low speeds in places dominated by people on foot rather than in cars. Another development based on this type of principle but with more modest infrastructure investment is the introduction of 20 mph zones. Indeed some cities are using 20 mph as a general speed limit across urban areas, with higher speeds on the arterial roads. Webster and Mackie (1996) found that 20 mph zones with appropriate traffic calming led to a reduction by around 60% of injury accidents and by around 70% of fatal accidents.

Speed humps are the most widely used form of traffic calming – especially in those countries where traffic calming has spread quickly (Great Britain and the Netherlands). However, they are not so well favoured in countries in which traffic calming was implemented later: for example, Austria and the Czech Republic. The effect on speed is well noted, but the impact on noise for nearby residents needs to be considered.

The speed reduction effect is usually perceptible 50 yards before and after the humps, but this is largely dependent on the hump heights and gradients. 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 20 mph zone.

Road infrastructure changes can take time and money, but there are some more temporary measures that can be used as a quick win, such as bollards and road marking. In the future it is envisaged that infrastructure will become significantly more intelligent, and there may well be a move towards dynamic speed limits for all routes. Ultimately when infrastructure cannot be upgraded at reasonable costs to the standard required for the existing speed limit the appropriate action will be to reduce the speed limit.

9. Technology

Automotive technology has made great strides in recent decades. Two analyses of developments over 50 years (Bayliss, 2008) and in the last 20 years (RAC, 2008) showed that there have been major improvements to almost all aspects of vehicle safety systems and that automatic speed control systems are now becoming more common. Moreover there is still considerable scope for recent and prospective innovations to be more widely deployed within the car parc.

There may come a point in the future when it is deemed appropriate to limit the maximum speed of vehicles through the use of technology. This technology in the form of mandatory speed limiters is available today and is in use in HGVs and coaches. The introduction of mandatory Intelligent Speed Adaptation will very much depend on there being public acceptance and political will to progress the idea. In the meantime voluntary speed limiters and adaptive cruise control are increasingly available on vehicles, and these may have a useful role to play in both encouraging and reminding people to drive within the set speed limit.

There also remains a wider question about the maximum speed that cars should travel and how this should be presented to the driver on the dashboard. Some vehicle manufacturers have addressed this concern through making the most common and used speeds as larger numbers on the speedometer. This is an area often talked about, as is the subject of maximum speeds and 0–60 mph speeds used for vehicle advertising. It would be interesting to establish whether these facts really do influence speed choice and attitudes.

According to the principles behind the discipline of behavioural economics the use of a speed ‘anchor’ that is artificially high in comparison to actual speeds may well have a negative effect. Black box technology is now available in a format in which speeds can be recorded and fed back to the driver to influence behaviour. This has been adopted particularly within the fleet market, which has reported fewer collisions. Certain products allow data to be downloaded to home computers, and there is likely to be real potential to use this type of initiative further in relation to insurance policies.

10. The Impact of Vehicle Design on Speed Limits

Over the past 50 years there has been a rapid improvement in road systems. Road vehicles are now able to travel at higher speeds, which have contributed to the economic development of countries. As the impact speed increases, the forces that vehicle occupants must absorb in a crash expand dramatically. Occupant protection systems have been found to be very effective at low and moderate speeds. However, they cannot adequately protect vehicle occupants from these kinetic forces at high impact speeds. This indicates that even with much improved vehicle technology it would not be appropriate to increase the speed limit without giving full consideration to appropriate crash speed and the risk associated with these different speeds.

According to WHO (2004) wearing seat belts in well-designed cars can provide protection at speeds of just over 40 mph in frontal impacts and of 30 mph in side impacts (excluding impacts with obstacles such as trees or poles for which the protection is effective only for 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 10 mph (Elvik et al., 2004).

11 References

Aberg, L., Larsen, L., Glad, A. & Beilinson, L. (1997). Observed vehicle speed and drivers' perceived speed of others. *Applied Psychology: An International Review*, 46(3): 287–302.

Batty, D. G. & Lee, I. M. (2004). Physical activity and coronary heart disease. *British Medical Journal*, 204(328): 1089.

Bayliss, D. (2008). *Some Changes in Motoring Characteristics: A Comparison of the Late 1950s and Today*. London: RAC Foundation.

Biecheler, M. B. & Peytavin, J. (1997)*. Drivers' Speeding Behaviour and Attitudes to Law Enforcement: A Multisite Roadside Survey in France*. Proceedings of Conference on Traffic Safety on Two Continents, Lisbon, 24–27 September 1997. In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/jtrc/safety/speed.html.

Brake (2004). *The Green Flag Report on Safe Driving 2004 PART TWO: Speed*. Retrieved 7 March 2012 from www.brake.org.uk/assets/docs/dl_reports/gf2_speed.pdf.

Charlesworth, G. (1984). *A History of British Motorways*. London: Thomas Telford.

Chauvin, J. M., P. Aubrée and J.F. Bedaux (1999). *Repenser la régulation du trafic : l'onde verte modérante. Revue Générale des Routes (RGRA).* In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/jtrc/safety/speed.html.

Denton, G. (1967). *The effect of speed and speed change on drivers' speed judgement*. In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/jtrc/safety/speed.html.

DETR (Department of the Environment, Transport and the Regions) (1998). *A New Deal for Transport – Better for Everyone: The Government's White Paper on the Future of Transport*. Retrieved 10 July 2012 from http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/adobepdf/187604/A_new_deal_for_transport_be1.pdf.

DETR (1999a). *20* mph *Speed Limits*. Circular 05/99. London: The Stationery Office.

DETR (1999c). *20 mph Speed Limits and Zones*. Traffic Advisory Leaflet 09/99. Retrieved 10 July 2012 from http://assets.dft.gov.uk/publications/tal-1999/TAL_9-991.pdf.

DETR (2000a). *New Directions in Speed Management: A review of policy*. Retrieved 7 March 2012 from http://webarchive.nationalarchives.gov.uk/20060213205515/http:/dft.gov.uk/stellent/groups/dft_rdsafety/documents/pdf/dft_rdsafety_pdf_504682.pdf.

DETR (2000b). *Tomorrow's Roads: Safer for Everyone. The Government's Road Safety Strategy and Casualty Reduction Targets for 2010*. Retrieved 7 March 2012 from www.lscp.org.uk/lrsu/www/downloads/tomorrows-roads_safer-everyone.pdf.

DfT (Department for Transport) (2006b). *Setting Local Speed Limits*. DfT Circular 01/2006. Retrieved 7 March 2012 from http://assets.dft.gov.uk/publications/circular-1-06/circular-1-2006.pdf.

DfT (2009). *Road vehicle emission factors 2009*. Transport Research Laboratory for DfT. Retrieved 30 May 2012 from www.dft.gov.uk/publications/road-vehicle-emission-factors-2009/.

DfT (2010b). *Reported Road Casualties Great Britain 2009: Annual Report*. Retrieved 11 July 2012 from http://webarchive.nationalarchives.gov.uk/+/dft.gov.uk/pgr/statistics/datatablespublications/accidents/casualtiesmr/rrcgbmainresults2009.html.

DfT (2010a). *Road Statistics 2009: Traffic, Speeds and Congestion*. Retrieved 11 July 2012 from www.bournemouth.gov.uk/PlanningBuildings/Planning/Policy/Local/CoreStrategy/CoreStrategyFiles/SubmissionFiles/BackgroundDocs/Websiteversions/4-19-RoadTrafficStatistics2009.pdf.

DfT (2010c). *Understanding Public Attitudes to Road user Safety – Literature Review: Final Report*, Road Safety Research Report No. 112. Retrieved 7 March 2012 from http://assets.dft.gov.uk/publications/understanding-public-attitudes-to-road user-safety-literature-review-112/rsrr1112.pdf.

DfT (2011c). *Average Time Spent Travelling by Main Mode: Great Britain, 1995/97 to 2010*. Table NTS0310. Retrieved 7 March 2012 from http://assets.dft.gov.uk/statistics/tables/nts0310.xls.

DfT (2011e). *Transport Statistics Great Britain 2011*. Retrieved 7 March 2012 from www.dft.gov.uk/statistics/series/transport-statistics-great-britain.

Directgov (2011). *The Highway Code, Control of the Vehicle*. Retrieved 7 March 2012 from www.direct.gov.uk/en/TravelAndTransport/Highwaycode/DG_070304.

DoT (Department of Transport) (1993). *Circular Roads 01/93*. *Road Traffic Regulation Act 1984, Sections 81–85 Local Speed Limits*. London: The Stationery Office.

Eddington, R. (2006). *The Eddington Transport Study.* Report for the Department for Transport. Norwich: HMSO.

Elvik, R., Christensen, P. & Amundsen, A. (2004). *Speed and Road Accidents: An evaluation of the power Model*. TØI Report 740/2004. Oslo: Institute of Transport Economics. In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/jtrc/safety/speed.html.

Elvik, R. & Vaa, T. (2004). *The Handbook of Road Safety Measures*. UK: Elsevier Science.

ETSC (European Transport Safety Council) (2010a). *Setting Appropriate, Safe, and Credible Speed Limits*. Speed Fact Sheet Number 07. Retrieved 24 July 2012 from www.etsc.eu/documents/Speed%20Fact%20Sheet%207.pdf.

ETSC (2010b). *Speed Monitor. ETSC's Newsletter on Speed Policy Developments in the EU. Number 08*. Retrieved 10 July 2012 from www.etsc.eu/documents/copy_of_Speed%20Monitor%208.pdf.

European Commission (2012). *Intelligent Transport Systems. Action Plan and Directive*. Retrieved 10 July 2012 from http://ec.europa.eu/transport/its/road/action_plan/action_plan_en.htm.

Fylan, F., Hempel, S., Grunfeld, B. Conner, M. and Lawton, R. (2006) *Effective Interventions for Speeding Motorists*. Road Safety Research Report No. 66. London: Department for Transport.

IHT (Institute of Highways and Transportation) (1998). *Urban Safety Management*. London: IHT.

Kloeden, C. N., McLean, A. J. & Glonek, G. (2002). *Reanalysis of Travelling Speed and the Risk of Crash Involvement in Adelaide South Australia*. In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/jtrc/safety/speed.html.

Kloeden, C. N., McLean, A. J., Moore, V. M. & Ponte, G. (1997). *Travelling speed and the risk of crash involvement*. In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/jtrc/safety/speed.html.

Kloeden, C. N., Ponte, G. & McLean, A. J. (2001). *Travelling Speed and the Risk of Crash Involvement on Rural Roads*. In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/jtrc/safety/speed.html.

Kooi, R. M. van der, & Dijkstra, A. (2003). *Enkele gedragseffecten van suggestiestroken op smalle rural wegen* (Some behavioural effects of non-compulsory bicycle lanes on narrow rural roads). Report R-2003-17, SWOV Institute for Road Safety Research, Leidschendam (The Netherlands). In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/Pub/pdf/06Speed.pdf.

Lerner, N., Singer, J. & Simons-Morton, B. (2005). *The Effects of Teen Passengers on Teen Driver Speeds and Headway*. In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/jtrc/safety/speed.html.

Lindkvist, A. (2009). *Variable Speed Limits for Different Purposes – Results from Swedish Trials and Strategy Considerations*. Conference paper from 16th ITS World Congress and Exhibition on Intelligent Transport Systems and Services, 21–25 September 2009.

McKenna, F. (2010). *Education in Road Safety: Are we getting it right?* RAC Foundation. Retrieved 7 March 2012 from www.racfoundation.org/assets/rac_foundation/content/downloadables/education%20in%20road%20safety%20-%20mckenna%20-%20080910%20-%20report.pdf.

Nilsson, G. (2004). *Traffic Safety Dimensions and the Power Model to Describe the Effect of Speed on Safety*. Lund: Lund Institute of Technology, Department of Technology and Society.

Nouvier, J. (1987). *Influence de la conduite sur autoroutes sur les vitesses pratiquées*. In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/jtrc/safety/speed.html.

OECD/ECMT (Organisation for Economic Co-operation and Development/European Conference of Ministers of Transport) (2006). *Speed Management*. OECD Publishing. Retrieved 7 March 2012 from www.internationaltransportforum.org/Pub/pdf/06Speed.pdf.

Plowden, W. (1970). *The Motor Car and Politics 1896–1970*. London: The Bodley Head.

RAC (2008). *Report on Motoring 2008: 20 Years of Motoring Technology*. Retrieved 7 March 2012 from www.rac.co.uk/data/media/file/pdf_1806.pdf.

Saad F (1983). *Perception et contrôle de la vitesse en conduite automobile*. In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/jtrc/safety/speed.html.

Salvatore, S. (1967). Vehicle speed estimation from visual stimuli. *Public Roads*, 34(6): 128–131.

Sexton, B. & Johnson, B. (2009). *An Evaluation of Options for Road Safety Beyond 2010*. TRL Published Project Report PPR397. Retrieved 7 March 2012 from http://news.bbc.co.uk/1/shared/bsp/hi/pdfs/23_02_11_roadsafety.pdf.

SWOV (Stichting Wetenschappelijk Onderzoek Verkeersveiligheid – the Dutch Institute for Road Safety Research) (2010). *Speed Choice: The Influence of Man, Vehicle, and Road*. Leidschendam, Netherlands.Retrieved 7 March 2012 from www.swov.nl/rapport/Factsheets/UK/FS_Speed_choice.pdf.

UK Motorists (2011). *A Brief History of Speed Limits*. Retrieved 7 March 2012 from www.ukmotorists.com/speed_history.asp.

van Schagen, I. N. L. G., Wegman, F. C. M. & Roszbach, R. (2004). *Veilige en geloofwaardige limieten: Een strategische verkenning* [Safe and credible speed limits: A strategic forecast]. R-2004-12. Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV.

Webster, D. & Mackie, A. (1996). *Review of Traffic Calming Schemes in 20* mph *Zones*. Transport Research Laboratory Report 215. Crowthorne, UK. In: OECD (2006). *Speed Management*. Retrieved 7 March 2012 from www.internationaltransportforum.org/jtrc/safety/speed.html.

Wengraf, I. (2012). *Easy on the Gas: The effectiveness of eco-driving*. RAC Foundation. Retrieved 15 June 2012 from www.racfoundation.org/assets/rac_foundation/content/downloadables/easy_on_the_gas-wengraf-jul12.pdf.

WHO (World Health Organisation) (2004). *World report on road traffic injury prevention*. Retrieved 10 July 2012 from www.who.int/violence_injury_prevention/road_traffic/en/.

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