# HALVING ROAD DEATHS:
# A CHALLENGE TO CHANGE MINDS AND WORK TOGETHER

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## 1 INTRODUCTION

For those with a professional involvement in or a political commitment to road safety, it is always exciting to hear of new national initiatives – and it is especially exciting to hear of an ambitious initiative in a country with a history of remarkable achievement in road safety, and with great potential regional influence.

So it is exciting to be able to take part in the kick-off meeting for Japan's new initiative to halve road deaths – and to halve them from a level of 75 road deaths (within 30 days of the accident) per million person-years, which lies between the third and fourth lowest in Europe. The European participants come to share experiences in the common endeavour to reduce death and injury on the roads, not only because some experiences in North-western Europe may be relevant to Japan, but also because some experiences in Japan may be relevant to Europe.

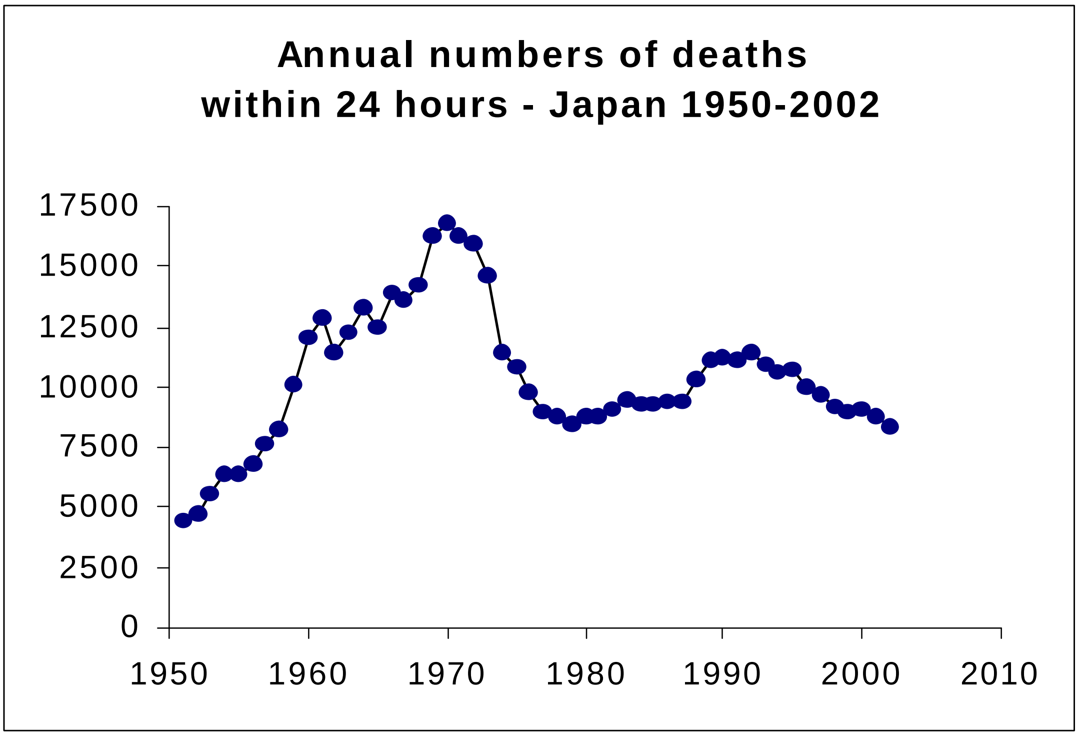


Figure 1 Annual numbers of deaths within 24 hours of the accident on the roads of Japan from 1950 to 2002

In common with many industrialised countries, Japan achieved in the early 1970s a reversal of the relentless year-on-year growth in the number of deaths on the road that had prevailed since the early 1950s. But the reversal in Japan came a year or two sooner than in most other countries, and clearly before the oil price perturbations of 1973-74. Moreover, the subsequent decrease achieved in Japan was much more rapid than in European countries, so that deaths in Japan were halved in less than 10 years, whereas in Great Britain, for example, this took well over 20 years from the downturn to achieve.

Japan's achievement in the 1970s was followed with great interest in Europe and was a source of inspiration and encouragement to those concerned with road safety in European countries. But accordingly the subsequent levelling off and temporary regrowth of the annual number of deaths on the roads in Japan were watched with anxiety from Europe, lest this indicated that progress in European countries towards their first halvings of the annual numbers of deaths might also be followed by a period of levelling off or even regrowth. Indeed, this possibility confronts a number of countries in North-western Europe which have recently achieved their first halvings in deaths, and the one which is well on its way to its second halving. Perhaps these countries can learn something from Japan's new initiative for a second halving in road deaths to help them to maintain their own progress beyond the levels of road deaths they have reached so far. In particular, with their ageing populations, European countries may well be able to learn from the great attention being given to the safety of elderly people on the roads in Japan.

## 2 THE CHALLENGE TO CHANGE MINDS

Road safety professionals and committed advocates of road safety know that the numbers of road deaths can be halved again, in Japan and in Europe alike – and indeed probably halved again after that. They know that it makes overwhelming socio-economic sense to do what is needed to halve road deaths, even though this means decision-makers diverting some resources from other attractive objectives, and people and businesses accepting some modest changes in the way they use the roads from day to day. And the basis for this claim is not some marginal or debatable balance of advantage, but a massive excess of benefit from reduced human suffering and material loss over modest cost in terms of resources invested and change accepted.

But those who need to be convinced are decision-makers, stakeholders and the public. The decision-makers and stakeholders, ranging from the national to the very local level in both the public and the private sectors, all have their own different agenda, among which reducing death and injury on the roads may not rank particularly highly. And the public do not realise how bad the problem is, because road death is rare and remote in the experience of most individuals. Nor do they realise how much better it could be made. They are therefore unready to change, however modestly, let alone to press their politicians for change. *This is the challenge to change minds*.

## 3 THE SCANDAL OF TOLERANCE AND GIVING AWAY LIVES

To change minds, all levels of society need to be made to confront the *scandal of tolerance* of current levels of death and injury on the roads. The main ways in which people can harm themselves and each other in everyday life as individuals in public places (that is aside from organised crime, commercial or political exploitation, or violence within the home) in Japan and Europe today are the following.

- *Misuse of guns* – which is scarcely tolerated at all

- *Behaviour that spreads disease* – which evokes very low levels of tolerance and a strong demand for countermeasures

- *Crime against the person and against property* – which evokes low levels of tolerance and high demand for countermeasures among better-off people, but may be more widely tolerated by some of the less well-off under the social and personal pressures of relative poverty and deprivation and lack of opportunities to earn a living legally

- *Misuse of substances* – for which there is a wide range of levels of tolerance and different attitudes to countermeasures – attitudes which have changed substantially in either direction within a generation (for example in relation to alcohol, tobacco and cannabis)

- *Misuse of motor vehicles* – for which there is widespread tolerance and only selective demand or support for countermeasures

Only the misuse of substances affects life and health on a comparable scale to misuse of motor vehicles, and there is almost certainly greater knowledge how to reduce these effects in the case of motor vehicles, if only the level of tolerance can be reduced (Allsop in Koornstra *et al* 2002, Appendix A).

Society also needs to be persuaded that the direct consequence of delay or failure in implementing known and affordable measures to reduce death and injury is *giving away lives* and condemning badly injured survivors to lifelong disability – contrary to the principle of respect for the preciousness of human life which is central to Japan's Fundamental Traffic Safety Programme (Central Traffic Safety Policy Council 2001).

It would be inconceivable for a health minister to announce that an inexpensive new treatment for cancer that would save 50 lives per year among mid-life patients had been found, but that it would not be made available through the national healthcare system. It would be similarly inconceivable for directors of a pharmaceutical company to be told how to reduce by 20 per cent certain very occasional fatal side-effects of a widely used and beneficial company product at an increase in price that is within the noise of year-on-year inflation, and then decide not to improve the product in this way.

Yet one European road safety minister has recently done the equivalent of the first, and car manufacturers have been doing the equivalent of the second for a decade, until the splendid and pathbreaking initiative of a Japanese company in 2001 in designing substantial pedestrian protection into a new high-selling model. A climate of opinion needs to be created in which decisions like these would be reported in the media for what they are – *giving away people's lives* – so that Ministers and companies would come under fire for failure to implement measures, instead of being criticised for trying to implement them, as is often the case at present.

When advocates of road safety measures are accused of limiting some people's freedom to use their vehicles on the roads, they can clearly and confidently respond that those who oppose safety measures are limiting everyone's freedom to use the roads without fear of untimely death or disablement.

## 4 RISK ON THE ROADS IS DISPROPORTIONATELY HIGH

Changing minds in this way means gaining greater attention for the problem of death and injury on the roads in societies in which many other problems are also calling for attention. For this purpose it is necessary to show not only that the gains from halving road deaths sufficiently exceed the cost to society of doing so, but also that the particular problem of these deaths ought to have higher priority than it has been given so far. A convincing answer is needed to the question: about a million people die in Japan every year – what is so special about these 10,000 who die on the roads? The answer is in four parts:

1. The deaths are accidental: they come without warning, which exacerbates the grief and suffering associated with any bereavement, and they can come at any age. In 2002, 10 per cent were under 20, 25 per cent under 30 and 55 per cent under 60 (Traffic Bureau, National Police Agency 2003), which means that the loss of life-years is much greater than from the same number of deaths from natural causes.
2. Even among accidental deaths, the risk per hour while using the roads is disproportionate to the risk elsewhere in everyday life. In round figures, in the years 2000-2002 there were 39,500 accidental deaths per year in Japan (Ministry of Health, Labour and Welfare 2001), of which 10,000 were on the roads. On average, Japanese people are awake for 16.3 hours per day (Ministry of Public Management, Home Affairs, Posts and Telecommunications 2001). Then if, like people in Europe, they spend on average about 1 hour per day using the roads, and if all the other 29,500 accidental deaths also occur in everyday life, it follows that their risk per hour while using the roads is about 15.3/2.95 – *i e* about 5 – times the risk in the rest of everyday life. And this ratio of 5 is an underestimate to the extent that some of the other 29,500 accidental deaths occur not in the course of everyday life, but in especially dangerous occupations, pastimes and situations which do not form a necessary part of everyday life for the great majority of people.
3. Use of the roads is not an optional activity, which people can choose to avoid – it is a necessary part of participation in society.
4. Many of the deaths can, as has already been mentioned, be prevented by known and widely acceptable means at manifestly affordable cost.

These arguments have been stated in terms of deaths, but they extend directly to serious injury and the resulting long term disability, which is in some cases so severe as to call into question whether death is the worst outcome of road accidents – for the victims themselves, for their associates or for society.

When advocates of road safety measures are accused of disproportionate concern, they can clearly and confidently respond that it is the risk people face when using the roads that is disproportionate.

## 5 VISION AND STRATEGY

Changing minds sufficiently to produce a strongly felt and lasting motivation for change that is sufficient to root out and overcome the prevailing deepseated tolerance of disproportionate numbers of people being killed or injured on the roads can be helped by promoting an inspiring vision or practical philosophy of safer road use, perhaps under the leadership of an influential person or group of people. To achieve the necessary change in the minds of decision-makers and stakeholders, the vision or philosophy needs to be far-reaching and long term, looking well beyond what is immediately achievable (OECD 2002).

In contrast, an effective strategy or plan of action needs to start here and now, and set out achievable risk-reducing measures for the foreseeable future, typically for, say, the next 5 or 10 years. There need, however, be no contradiction between a far-reaching long-term vision or philosophy and a challenging yet achievable, and thus necessarily more modest, shorter-term strategy for the foreseeable future. If properly communicated and understood, both the ultimate vision or philosophy and a strategy for the next foreseeable steps towards it can serve their respective purposes side by side (ETSC 2003).

## 6 THE VISION OR PHILOSOPHY

Probably the best known vision for road safety is the *Vision Zero* adopted in 1997 by the Parliament of Sweden:

> "The long-term goal … that nobody will be killed or seriously injured as a result of a traffic accident within the road transport system" (Ministry of Transport and Communications Sweden 1997).

There can be little doubt that at a time when the risk of death or injury when using the roads (even in those countries where it has been most successfully reduced so far, including Japan) is so disproportionately high compared with the risk of other everyday activities, the Vision Zero has been an inspiration to all workers for road safety to set their sights high, to keep up the pressure on decision-makers for more rapid and determined implementation of known measures to reduce death and injury on the roads, to motivate researchers to develop new measures, and to ward off any tendency to settle for soft options or to start to acquiesce in existing levels of risk. It has been adopted by a number of European countries, either explicitly or in the form of statements such as

> "Death and injuries in traffic are unacceptable – each accident is one too many" (National Commission for Road Safety Denmark 2000).

This is the one European vision that matches the Japanese Fundamental Traffic Safety Programmme's

> "ultimate goal of total prevention of traffic accidents and traffic casualties" (Central Traffic Safety Policy Council 2001),

while other countries adopting the Vision Zero, including Sweden itself, accept the continued occurrence of traffic accidents, including ones that give rise to slight injury.

But not all European countries accept the Vision Zero. The author has pointed out (Allsop 2002) that there are limits to the costs that it is reasonable to incur or impose in order to protect against risks in road traffic when there are many other pressing calls upon resources, including opportunities to save lives and reduce suffering elsewhere in society. This is also recognised in the road safety programme for Finland (Ministry of Transport and Communications Finland 2001), even though its starting point is the Vision Zero. The author has also pointed out that society accepts risk of death and injury in the course of beneficial activity in other areas of life, and people are unlikely to be willing to forego freedom in using the roads to the extent that would be needed to eliminate all risk of death or serious injury in doing so.

People using the roads have the right to be protected from other people's errors and irresponsibility. They also have the right to be informed and advised how to reduce risk, and to expect known and affordable measures to be taken to protect them from their own errors. But the resulting safety is not an end in itself – its purpose is to allow people to exercise their more basic right to live their lives to the full, even when this means taking some risks. Safety is for living, and living is much more than just staying safe.

This is not only a matter of philosophy: it also has practical implications for road safety policy. Because use of the roads is such an intrinsic part of the lives that people want to be free to live, policies and measures that affect use of the roads have to gain and retain the acceptance of the vast majority of the people if they are to be implemented. This is true even of policies and measures that will manifestly reduce death and serious injury. If the Vision Zero is accepted as a long term basis for road safety policy, and substantial progress is made towards it, then possibly within 10 years and almost certainly within 20 years, policies and measures are likely to come up against the limits of public acceptability in terms of limitations on freedom to use the roads. And to try to overstep these limits would be to risk losing a good deal of the ground that had been gained up to that point.

It is for reasons of this kind that the Vision Zero is not accepted as a basis for road safety policy in Great Britain, where the Government's Commission for Integrated Transport has recently had commended to it the more pragmatic vision of

> "reducing the risk of death per hour spent using the roads to the average risk of death while engaging in other everyday activities"

## 7 STRATEGY – THE CHALLENGE TO WORK TOGETHER

The idea of a road safety strategy, that is a plan of action to implement risk-reducing measures for the foreseeable future, typically for the next 5 to 10 years, is a familiar one in Japan, because Japan has had 5-yearly road safety strategies since the early 1970s. It is nevertheless worth recalling the rationale and mechanism for adopting a road safety strategy, and the advantages to be expected from doing so.

Reducing the number of road deaths and injuries in practice requires a wide range of people and interests to act cohesively in many different ways which interact strongly and need to reinforce one another. *This is the challenge to work together*.

Professional and ethical responsibility for road safety is spread widely over many kinds of people in a range of commercial, professional, governmental and community organisations. Some of these, like road safety engineers and officers, have duties defined explicitly in road safety terms. Others, like highway and traffic engineers and bus drivers, have roles that are defined in other ways but have quite obvious road safety implications. Yet others, like architects, town planners, teachers and doctors, may not realise how much their activities can influence road safety unless this is brought to their attention by suitable advice or training.

Different kinds of action to improve road safety are interdependent in many ways: the engineering of the roads and of the vehicles need to be compatible, and both need to be compatible with the capabilities, limitations and behavioural characteristics of the road users. Different kinds of action also compete for resources, most explicitly in the allocation of government expenditure and in management decisions in business, but also in individuals' decisions about their use of time and money for travel and for vehicle ownership and maintenance.

Some aspects of this interdependence and competition are naturally recognised and addressed by those concerned, but this does not necessarily happen to an extent that is commensurate with the scale of avoidable death, injury and damage in road accidents, because it may not be in the interests of the people and organisations concerned. The range of people and interests involved and the complexity of the interdependencies and tradeoffs in use of resources are such that a more systematic approach is called for in order to address the challenge to work together.

The value of setting the whole range of road safety action in the context of a strategy lies not only in the existence, and the real prospect of successful implementation, of a coherent programme of concerted action of all kinds, but also in the effects on the stakeholders of being challenged to work together by being fully involved in the process of formulating the strategy and keeping it up to date.

This process, if it is so conducted as to achieve the full involvement of all those who can contribute to making use of the roads safer, can deliver:

- a rationally based consensus on, or at least acquiescence in, an agreed programme of action;
- motivation and commitment on the part of all stakeholders from whom contributions to its implementation are required;
- a framework within which stakeholders can each plan for their contribution to the action in the knowledge of what others are planning to contribute;
- explicit identification of synergies and tradeoffs with public policy in other areas;
- coherence and persuasiveness in gaining at least acceptance of the envisaged action, and where possible enthusiasm for its success, on the part of the public and of business;
- a firm basis for cross-party political will to allocate the required public expenditure;
- ranking of actions in terms of cost-effectiveness to inform their sequencing within budgetary constraints, having regard also to equity among different beneficiaries; and
- a clear framework for monitoring the effectiveness of different actions and progress of the programme as a whole to inform the continual updating of the strategy in the light of experience and changing circumstances (Allsop 2001).

Because road safety action is typically a highly cost-effective use of resources, it can be helpful to make this explicit by attributing monetary values to the reduction in risk required to save one (unknown) person from death, from serious injury or from slight injury (see *e g* Evans 2001). In doing this, it is important to be clear that it is not particular people's lives or suffering that are being valued, but the reduction in risk to everyone that is required to prevent death or injury. Making this cost-effectiveness explicit in the strategy should lead to greater allocation of resources to it, and thus to more action, than would be the case in the absence of a strategy. Systematic consideration of interdependencies within the strategy and the enhanced motivation and commitment of the contributors in response to the challenge to work together should make the action more effective. Ranking in terms of cost-effectiveness should make the sum total of affordable action more cost-effective. The strategic approach should thus lead to more action, more effective action and more cost-effective action to improve road safety

## 8 TARGETS

Targets that are soundly related to the stated measures and their likely effectiveness can provide both clear motivation for stakeholders from whom action is expected and meaningful yardsticks against which progress with implementation of the strategy can be measured. Such a sound relationship between targets and measures can be reached by stakeholders either first agreeing on the measures and then deducing matching targets, or first deciding on targets and then finding a set of measures that makes the targets achievable, or, probably most typically, by a subtle mixture of these two approaches.

It matters little just what mixture of the two approaches is used, so long as the process leads to the agreed measures and associated targets being mutually consistent and gaining the ownership and commitment of all the affected stakeholders. In this process it is also important to find a widely acceptable balance between challenge and achievability of the targets. Targets that go beyond what is achievable in terms of the likely effects of the foreseeable measures can demotivate instead of motivating, while targets that could be reached without a high level of implementation of all the envisaged measures can induce widespread complacency, with each stakeholder tempted to feel that only part of what they could contribute is really needed.

It is of course possible simply to choose targets in the form of appealingly low numbers of casualties or levels of risk without prior consideration of just how they might be achieved. However, unless targets chosen in this way can be matched quickly by practical strategies for their achievement, these targets act rather as aspirational substitutes for a vision or philosophy than as a tool for motivating and monitoring the implementation of a particular road safety strategy. Moreover, once such aspirational targets have been set, it can become difficult subsequently to set more modest interim targets in relation to a specific safety strategy without creating apparent contradiction and consequent confusion (ETSC 2003).

Well-set targets provide a basis for quantitative monitoring of progress in implementation over the duration of the strategy, helping all stakeholders to benefit from experience as it is gained, and to adapt the strategy to changing circumstances. Achievement ahead of target in some respects can point to greater opportunities than were foreseen, whilst falling behind target in other respects can draw attention to unexpected difficulties and the need to reallocate resources. European experience in the setting and use of road safety targets has recently been summarised by the European Transport Safety Council (ETSC 2003).

## 9 SOME CURRENT ISSUES FOR JAPAN

The fact that Japan has had successive road safety strategies since the early 1970s, the current one comprising Chapter 1 of Part 1 of the cross-modal Fundamental Traffic Safety Programme for the years 2001-2005 (Central Traffic Safety Policy Council 2001), raises the question why the annual number of deaths increased between 1980 and 1992, and what more may be needed to maintain and accelerate the decrease which has been achieved since 1992.

It would hardly be proper for a guest who has spent no more than a couple of months in Japan in 25 years to venture to answer this question. It may, however, be useful to set out some related issues to help to stimulate creative discussion during this kick-off meeting and the follow-up to it.

Chapter 1 of Part 1 of the Fundamental Traffic Safety Programme is formidably comprehensive. It is hard to think of any measure or policy that might improve road safety consistently with continued high levels of car ownership and use that is not either explicitly or implicitly included. In contrast to the Netherlands or British model of a road safety strategy forming a component of an integrated transport policy, the Japanese programme seems almost to be a comprehensive road transport policy built upon the objective of reducing death and injury.

The result is that alongside what may be called *front-line* measures and policies that aim very directly to reduce death and injury (such as treating high-risk sites by road safety engineering, reducing vehicle speeds in residential areas, improving protection offered by vehicles in crashes, helping elderly people to adjust to their changing situation as road users safely and improving rescue services for the injured), there are other, what may be called *supportive*, measures whose casualty-reducing effect, though clear in principle, is less direct, and may well be modest (such as bus priority measures and cycle parking facilities), and some whose relevance to casualty reduction might even be seen as tenuous.

This seems to create scope for hard-pressed stakeholders to be able to feel that they are contributing strongly to the safety programme, when in fact their efforts, substantial in themselves, are in areas that can yield only modest casualty reductions.

*It seems to be worth considering whether a clearer focus on direct casualty reduction might be achieved by structuring the next fundamental traffic safety programme so as to distinguish clearly between front-line casualty-reducing policies and measures on the one hand, and wider supportive measures having potentially useful but more modest and less direct casualty-reducing effects on the other, and to emphasise priority for the front-line policies and measures.*

The range of new and enhanced activities envisaged for national and local governments under the current Programme seems very ambitious in terms of the generality of the statements about what will be done, in terms of the skills and capabilities required and the likely cost, and in relation to the 5-year timescale of the Programme.

This seems to create scope for the motivation of hard-pressed authorities to be undermined by the variety and sheer extent of new demands upon their management capacity, human resources and budgets, resulting in their contribution to casualty reduction being less than it might be. It is also relevant to motivation that monetary values currently attributed in Japan to prevention of death or injury are low compared with those used in a number of OECD countries.

*It seems worth considering whether the next fundamental traffic safety programme might more explicitly set out the demands upon human resources and budgets implied by the envisaged activity, and how national and local governments are expected to make these resources and budgets available and deliver the envisaged activity within the period of the programme (whether that be 5 years or longer) – thus making for a more clearly achievable programme, even if perhaps at first sight a less ambitious* *one. The same might also apply to activities which impose costs upon and require effort by business or non-governmental organisations. It might also be timely to review the monetary values attributed to prevention of death or injury. Creating the will in all quarters to allocate the necessary resources requires meeting the challenge to change minds.*

A number of European countries, even including some of the smaller ones, have found one of the greatest challenges in implementing their road safety strategies to be to secure consistent delivery by local authorities over the whole period of the strategy of the contributions which those authorities accepted as being appropriate when the strategies were being drawn up. This stems in part from the democratic nature of the local government institutions, and in part from the number of different local authorities and their relative institutional independence from national government.

In terms of population, Japan is half as large again as the largest Western European country, and ten or more times the size of some of them. In such a large country, the potential difficulty of involving all the stakeholders fully in the development of each successive road safety strategy, gaining their ownership of it and maintaining their motivation throughout its duration, is probably more than proportionately greater than in smaller countries.

*It therefore seems worth considering what scope there may be for achieving deeper involvement of the stakeholders in the formulation of the next fundamental traffic safety programme than may have been the case hitherto, and thus achieving a fuller sense of ownership of the programme by them, and a level of commitment which can more readily be maintained over its duration – in short, for addressing more fully the challenge to work together. The mechanisms that serve to achieve deeper involvement in formulating the programme may well be able to be kept in place for its duration to maintain commitment to its implementation.*

## 10 CONCLUDING REMARKS

The task of halving road deaths has been explored here as a *challenge* to all concerned *to change minds and work together*. Meeting this challenge is not a once-for-all task, but a continuing process in which the road safety strategy and its implementation are kept under review and regularly updated in the light of monitoring of changing circumstances and of progress towards targets. Deaths can be halved if enough people and interests are convinced that they want it to happen and are willing to work together to make it happen. Colleagues in Europe look forward to following progress in Japan and continuing to exchange experiences with their Japanese counterparts.

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**Vision for a safe road transport system**

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## Background

The history of traffic safety is long and has had many directions and strategies as tools for improvement of the situation. While countermeasures has been directed towards all parts of the system, the general approach has been to put the responsibilities for road accidents and their consequences on the individual road user. Investments have been mainly introduced on the basis that they are cost effective, in that the return on the invested money has been bigger than the investment. This is contrasting to the general philosophy in the society, where actions are based on the desire of the citizens to tackle problems and especially those that pose a threat to life and health. Although it seems logical to choose countermeasures that are cost effective, the question if they should be put in place or not are normally a political question, or a question of fulfilling obligations to regulation or other expectations.

The road transport system is an open system with a variety of stakeholders. These stakeholders represent both organizations that are driven by political or ideological issues, as well as those driven by commercial and market forces. They are by other words driven by a variety of motives, not only what is cost efficient. Regulation has been put on some of them, and in same aspects, but in general very few have got an obligation in a broader sense to protect life and health in the road transport system.

While it is important that individual road users are motivated to follow, and obey, basic rules of the road transport system, it is easy to classify the road transport system as an ill functioning man machine interface. Small errors can lead to fatalities and serious injuries. Due to the enormous impact in terms of health losses to the citizens, it should be normal to look for organizational and systems oriented actions to protect the citizens rather than concentrating only on the behavior of the individual. This does not by any means lift the burden from the individual to follow rules, but should also put a high demand on those that are responsible to modify the system. In order to have a common understanding of driving forces to change among a variety of stakeholders, a vision of what the future should look like could be helpful, if not necessary.

## The Strengths of a Vision

A vision is an image of a future situation and its qualities. It is a way to assemble individuals, organizations and a whole society around an idea of a direction into the future. In road safety, it is an image of the future in terms of the qualities of the road transport system. It is not likely, and perhaps not desired, to be a full-scale model of what it exactly looks like, but rather the qualities for the different components of the system and how they interact. It is also a tool for a democratic society where citizens can relate to long term values and get involved in the way they are fulfilled.

In the road transport system, with so many stakeholders, a vision is probably more useful than elsewhere. The nature of the situation, where stakeholders gradually and over a very long period of time should improve components and interfaces of the system is an important ingredient in the importance of a vision. This is a contrast to a future that is planned and regulated.

A vision will also allow stakeholders to develop subsystems in their own, but still knowing they will contribute to the vision. It is also of major importance, that while gradual improvement is essential, it is easier to understand what is the long-term sustainable solution. While safety has been improved, it is likely that the majority of costs are spent on modifying what has already been modified before . If things had been done right already from the beginning, we might have saved time and money to spend on new items and solutions.

A vision is not an action plan, and will thereby allow stakeholders to work out how they can fulfill the visions with their own overriding motives in relation to the citizens. Possible conflicts and synergies with other motives and goals can also be worked out at an earlier stage, thereby avoiding conflicts and gain support from other areas and aspects of the road transport system.

**What a vision for the future road transport system should include.**

The elements of a vision for the safety of the road transport system are important to base on the problem description. While most emphasis has been put on the responsibility for the individual road user, it is the professional society that would have to develop the system to be sustainable. A vision should therefore focus on the future on the entire system, and how the professional society would take onboard the responsibilities for creating such a vision.

The vision should also include human values, the relation to the citizens and what the driving forces to change are. A vision should also give a direction for how possible conflicts with other benefits and drawbacks of the road transport system should be handled. While safety is a core quality of the road transport system, mobility is the functionality. This functionality should be defined further to allow a vision for the quality to be developed.  In the end the vision should allow the citizens to have a sustainable mobility.

**A problem description**

The road transport system is without doubt a poor functioning man/machine system. The citizens have good motives for staying alive and healthy, but are not given the possibility to travel from A to B in a way that is safe. Although the risks for the individual is moderate seen over a short period, on the society level and over time the road transport system generates major public health problems. In most of the developed countries, up to approximately five percent of the population will either get killed or lose their health for a long period of time.

While it can be seen, that the users of the system is not behaving in a way that is desired, even well motivated people following in general rules are at risk. A small proportion of the population is obviously acting in a way that is criminal, and pose high risk to themselves and others, but they are hardly the core part of the health problem. In general, most citizens should be seen as normal people, with all their faults but also skills and good motives. A safe system should accommodate such a population and help it to stay alive.

While the vast majority, if not all crashes with health losses are results of human failure and even breaking rules, the link between the action of the user and the resulting loss of life and health is not fair. Even minor misjudgments and errors might lead to a serious outcome, and while the error would be seen as minor if there was no crash or no injuries, the fact that it led to a major health loss is sometimes seen as the magnitude of the error.  It seems, as if it is the outcome that drives the moral standpoint of someone's faults.

There are, however, other systems and environments in the society that handles great risk that are tolerant to errors and misjudgments and even violations. The power supply system is an example of a man machine interface that is well functioning.

There are a few hypothesizes that might explain why the road transport system has developed into this situation. First of all, there is a historical explanation in that the society in the early stages of the road transport system put the legal and moral burden on the individual user. Unlike other publicly or professionally used systems, there is none legally responsible for the safety of the whole system.

In the road transport system, there is also a tradition to balance health to the benefits of the system. Life and health is as a result a part of the equation to provide the society with a good mobility, rather than being a limitation of the mobility. This has been possible as the legal responsibility is mainly put on the user, and the collective investments are only beneficial if the return of investment is higher than investment itself. This is not a common way to handle man machine systems that most people are forced to use.

**Human values from a professional perspective**.

If a problem analysis would lead us into, that the road users are victims of an ill functioning man machine system, even if we can see that much of the problems arise from road users not using the system according to rules, the responsibility for modifying the system will fall on the professional society. While the road users cannot change the system on their own, just be a part of the change, the designers and providers of the components of the system must take on the task to change the safety within the system. Such a task should be based on human values and a long-term vision for what will be delivered to the citizen.

It is logical, that while if the responsibility for life and health will fall on the road user, actions to improve the safety will be balanced to benefits. It is equally logical, that if the responsibility for creating life and health for the citizen is put on the professional society the consequence is quite different. In that case protection of life and health becomes paramount. It is not likely that a professional body in the society can negotiate with the citizens on a rational basis to provide a balance between life and health and benefits, which would mean that the individuals right to life and health is negotiated with the benefits of the collective in the same system. Therefore, a human value approach to safety is logical as well.

It is equally logical that the responsibility chain is modified. The responsibility for providing the citizen with a safe system will be the role of the professional society, as well as making sure that the road users are responsible for acting in a safe way.

**A vision for a safe system**

The definition of a safe system is based on what health issues that are focussed, and under which conditions it is safe. While a fatality is the ultimate loss of health, there are also a number of injuries that will, or can lead to serious health losses. The conditions under which the system is safe could me more complicated in theory, but will have minor implications on how the vision is turned into reality. While some would probably claim, that a vision of a safe system could only apply to road users that would follow certain rules and have certain vehicles, the road transport system does not allow anyone to travel under his or her own premises. If the system would, as an example only apply to sober road users, drunk drivers pose a high risk to other road users. The system would therefore protect other road users from drunk drivers, which in turn would not exclude the drunk drivers from the vision of a safe system. Therefore, there is little point in excluding anyone from the vision. From an ethical viewpoint this would be even more complicated.

A safe system would have to be based on some safety philosophy, otherwise it would be meaningless as a guiding tool for the professional society. It would without doubt have to be based on a systems approach.

**The Vision Zero**

Vision Zero was launched as a political initiative in the late nineties. The vision states that none should be either killed or seriously injured by the road transport system. The content of the vision was taken by the Swedish Parliament in October 1997. The vision is based on four main elements; ethics, responsibility, scientific approach and driving mechanisms for change.

In terms of ethics, the main element is that life and health in the long run cannot be traded of to benefits of the road transport system. The consequence of this is that mobility gradually will become a function of safety. This is an approach that is well known from the occupational health and safety area.

The responsibility chain has been changed in a way that it is the system providers that are ultimately responsible for the inherent safety of the system. It is the users responsibility to follow rules. But if the users are not doing what is expected, the responsibility falls back on the system providers. A new body has been installed that has the role to overlook if this chain is working. While the responsibility chain is not given a legal status at this point, it is understood that it is a principle among all stakeholders. It should be understood that this chain of responsibility would give legitimacy for the system providers to enforce or restrict the road user heavily.

The safety philosophy has two elements. The first is that the design of the road transport system should be based on the failing human. Infrastructure, vehicles, speed limits, enforcement etc should all be based on that the human is likely to make mistakes, but that these mistakes should not lead to a health loss. It is at the same time a guide for the actions taken to motivate and enforce that the road users are following certain rules. These are mainly those areas that the rest of the system will be based on. These are mainly speed compliance, seat belt use (and other protective devices like helmets) and drivers being sober.

The other basic element of the safety philosophy is that the system should be based on the human tolerance to mechanical force. This is the limiting factor of the entire road transport system. While this limiting factor is in the end linked to kinetic energy, it is important to stress that prevention all the time should include the whole chain of events that lead up to a health loss. With this it should be understood that all possible harmful events should be exposed to the whole variety of methods to prevent, from drivers access to the road transport system to occupant protection in a crash.

The limiting factor being related to kinetic energy and biomechanics of the human is also an explanation to why speed, restraint use and being sober are key elements of road user behavior. This is also why it would be of help to support such behavior also by technical systems, as the are so crucial to the design of the rest of the system.

The fourth element of vision zero is the driving forces to change. While it has been very much the society's suffering from costs, it has now following the logic behind responsibility the demand from the individual citizen that is the main driving force. It is therefore implicit that the professional society is supposed to deliver safety to the citizen individually and collectively. This delivery is as has been stated earlier possibly conditional on that the road user will take his or her responsibilities. The responsibility chain will though still lead to that these conditions will be removed if the citizen cannot or refuse to comply with rules and regulation

**Initial outcome of Vision Zero**

While a vision is an image of the desired future, it is expected to give input for the near future as well, especially in terms of new innovations that will meet the demand from a much higher expectation on sustainability and effectiveness. It is therefore of interest to see if there are any signs of such a development.

In Sweden, the vision zero has without doubt influenced the development of road safety. One of the most striking examples is the changed view on infrastructure design. While it has been a tradition that infrastructure design for safety should be related to accident prevention, it has now been turned over to injury prevention. In reality this means that roads are mainly designed to minimize injuries in a crash rather than avoiding them. This has led to a large mid barrier installation program on two and three lane roads with a reduction of fatal injuries on these roads of approximately 90%. This has been achieved to a cost that is at least ten times lower than earlier prevention programs.

The design of built up areas has also been changed, where it is now a policy that the actual speed in conflict spots should not be more than 30 km/h. Also outside built up areas, there is a new speed limit system being developed, where the speed limit in the long term will be linked to the crash protection level of the infrastructure. This approach is very close to the newly introduced rating system for infrastructure, called EURO/RAP.

Because the driving mechanism for change is related to the citizen’s demand for safety, it is important that the quality level for products and services within the road transport system are transparent. Sweden has therefore been very active in promoting several rating systems like NCAP, RAP and also national systems like the rating systems for goods transport. These rating systems are meant to give credit to those stakeholders that invest in safety, and to make the citizen aware of both positive development as well as what can be considered to be optimal quality of products and services.

Both automotive industry and other commercial operators in the road transport system have reacted in a very positive way to these open quality assessments.

A recent development that is in line with the approach to professional responsibility is the OHS area, where the OHS regulations are applied to transport. Another positive development is the trend towards merging environmental sustainability with safety. Both quality systems as well as criteria like fuel consumption are well suited to support both safety and environment. This has strengthened the market for safety substantially, where also the Swedish National Road Administration (SNRA) has started to act as a good consumer of the road transport system in order to serve as a good example. Since a few years, SNRA has a purchasing policy for cars and rental cars as well as for heavy goods transport. Starting 2004, all trucks purchased by SNRA must have alcohol interlock, and 2005 all trucks used in operations related to SNRA must have this device. This is a very powerful strategy that will be used extensively to enhance quality and introduction of adequate technology that support safety.

**Summary**

In summary, it can be expected that a long term’s vision for safety based on human values can play an important role in developing the road transport system. If the vision is combined with strong driving forces meant to deliver health to the individual citizen, most if not all stakeholders can relate to such a vision. This should be able to happen irrespective of the motives a stakeholder has, as all of them in one way or another are there to deliver a value to the wider community.

A shared vision should be based on a clear approach to the quality of the system, so that each stakeholder can understand the expectations. This could also be supported by openly present the level of quality that each stakeholder has reached and pointing out what would be the optimum quality.

The results so far of a strategy based on a vision are promising, although it should be stressed, that building a safe road transport system will always take a long time.

## FEWER CRASHES AND FEWER CASUALTIES BY SAFER ROADS

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### 1. Human error and human tolerance

An 18-year-old youth has just passed his driving test. One Saturday night he is driving his friends home from a disco. The teenager has recently bought a second-hand car. The way home takes them over a winding dyke besides a river. It is raining. The teenager misjudges a bend. He is driving too fast so he cannot adequately correct for the bend. The car drives into the river. Because the youths are not wearing a seat belt, they are thrown out of the car and drown. The following morning a passer-by discovers the crash.

Cause? A young, inexperienced driver, not wearing a seat belt, driving at night in the rain with an inappropriate speed along a road without a barrier, an unexpected sharp bend, bald tyres? All these factors could have contributed to the accident and to the severity of the outcome. Often a critical combination of circumstances is involved (OECD, 1984). Pointing to one single cause, finding one culprit for a crash, does not do justice to the complex reality and – unnecessarily – limits the real opportunities to prevent crashes or the severity of crashes.

Research has shown that the human factor plays a role in practically all crashes. Some have reacted to preventing *human errors* by equipping road users better to carry out the driving task: better education, more public information, and more police surveillance. The insight is slowly beginning to grow that road user mistakes are just a normal part of traffic, and that they should not only be punished for 'bad' behaviour, but that mistakes should be accepted. Furthermore, we know from other circumstances, such as the employment environment or other means of transport (Reason, 1990) that an effective way of eliminating human errors, or at least the chance of limiting them, is by adapting the environment. This is referred to as 'paradigm shift'.

It is not possible to prevent every crash. They will continue to occur also in an adapted environment. The question is then whether the circumstances can be adapted in such a way as to exclude, or practically exclude, severe injury. You can read the following on the website of the EuroRAP programme: "On the racetrack, drivers can walk away from 300 km/h crashes because track and vehicle crash protection work together" (www.eurorap.org). This concept, as in the visions from Sweden (Vision Zero) – see also www.vagverket.se - and the Netherlands (Sustainably Safe) – see www.swov.nl and also paragraph 5 - , leads to and forms the second cornerstone of the earlier referred to paradigm shift: the *human tolerance* as a design parameter of the road transport system. To adjust the present road traffic system to the requirements of human error and human tolerance, an enormous transition is needed. First of all, we do not possess the knowledge of all components to be able to transpose the conceptual ideas to the specific layout of the various components of the system. Furthermore, it is clear that integration is necessary to steer the various system components. This integration is not yet generally accepted, and a holistic approach, in the theoretical sense, is probably a smaller problem than in the steering sense. Finally, it is not to be expected that adapting the present system to one that meets the requirements of human error and human tolerance will be easy, and ready in the short term. In particular and referring to Holland's road structure, the necessary investments will be considerable. In addition, such expenditure needs public support. It will be necessary to make *Many Small Steps Forward* (so-called incremental change) and decision-making procedures will have to be agreed upon in order to set these Many Small Steps by Many (independent) Stakeholders in the right direction, and to involve efficiency considerations.

### 2. Safety quality of roads

### 2.1. Indicators for safety quality of roads

There are different ways of scoring the safety quality of a road. First of all there is the possibility of expressing the lack of safety in the frequency of crashes occurring, the number of casualties (deaths and injured) thus resulting, and the ensuing costs. First of all, it will have to be kept in mind that crashes are relatively rare occurrences (seen in terms of statistics). Looked at this way, there are frequent accidents hardly anywhere, and the majority of road users are rarely involved.

Another question is that a crash happening does not say enough about the risk being run somewhere. Thus, it is also important to know the extent in which the individual is exposed to a risk, and crashes. In general, crashes are related to 'exposure to risk' (Hakkert & Braimaister, 2002). Exposure to risk is rarely measured directly, but estimated indirectly.

If we want to express the safety of roads, that can be done by dividing the numbers of crashes by the amount of traffic that makes use of that road. This, for example, produces a ratio for road segments of the number of crashes (fatal and/or with injuries) per vehicle kilometre travelled. In the case of intersections, the number of crashes is related to the number of vehicles entering an intersection.

In Table 1, the risks are given for various road types in the Netherlands. There appear to be large differences in risk. The can be largely explained by the road and traffic circumstances: which vehicle categories use the road, what their driving speeds are, how their driving directions are separated, and what the intersection solutions look like.

| Road type | Speed limit (km/h) | Mixed traffic | Intersecting / oncoming traffic | Injury rates per million km |
|---|---:|---:|---:|---:|
| Residential areas | 30 | Yes | Yes | 0.2 |
| Urban street | 50 | Yes | Yes | 0.75 |
| Urban artery | 50/70 | Yes/no | Yes | 1.33 |
| Rural road | 80 | Yes/no | Yes | 0.64 |
| Express road or road closed to slow moving vehicles | 80 | No | Yes | 0.3 |
| Motor road | 100 | No | Yes/no | 0.11 |
| Motorway | 100/120 | No | No | 0.07 |

Table 1. *Injury rates in the Netherlands in 1986 on different road types*

Expressing the ratio between crashes and traffic volume in one number assumes a linear relation. This relation, referred to in North American literature, as Safety Performance Functions (SPF) appears normally not to be linear, but shaped as in Figure 1 (Hauer, 1995). If a SPF is not linear, the use of a ratio is only limited, if not incorrect.

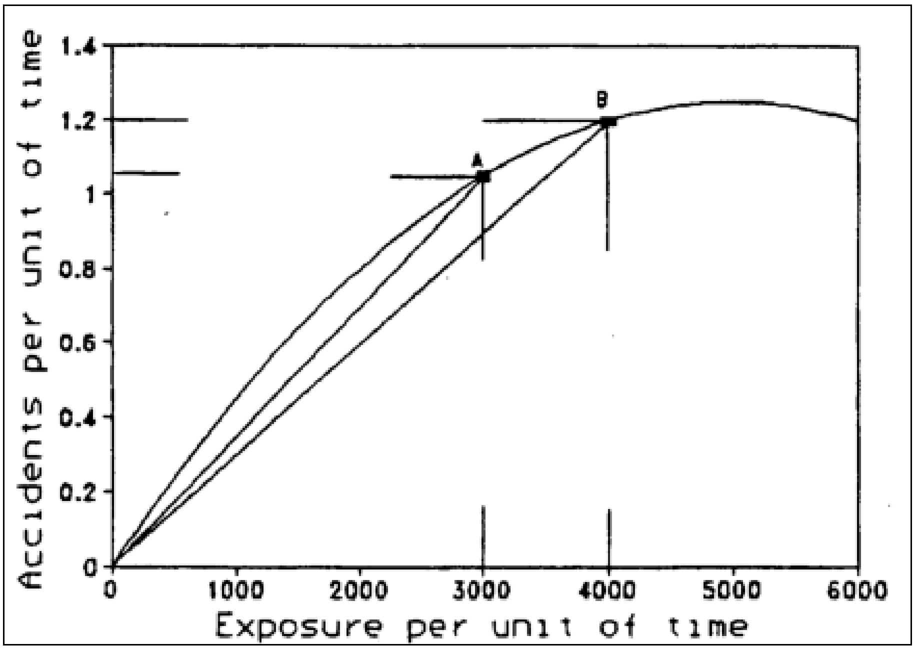


Figure 1. *Safety Performance Function and accident rates. From: Hauer (1995)*

The significance of this ratio not being linear is of great importance, not only scientifically, but also for the road safety implications of certain measures that influence traffic volumes of roads in a network. The question of optimising is here relevant. In other words, certain traffic volumes on roads in a network can be searched for, that can be regarded as the 'optimal safety load' of a network. It is not difficult to see that sticking to fixed ratios can lead to wrong conclusions. In the American Interactive Highway Safety Model (IHSDM) (www.tfhrc.gov), 'a road safety evaluation software program that marshals available knowledge about safety into a more useful form for highway planners and designers', there is a so-called Crash Prediction Module in which 'base models' are used as part of the crash prediction algorithm (Harwood et al., 2000). IHSDM refers to rural two-lane roads. These models distinguish between road segments and intersections (of various types).

Apart from various parameter estimates in SPF for different road types, the geometric features and traffic management measures also influence the ultimately expected number of crashes. This is given in the Accident Modification Factors (AMF). In the previously mentioned IHSDM model, AMF has been developed for: lane width, shoulder width, shoulder type, horizontal curves, grades, driveway density, two way left turn lanes, passing lanes, and roadside design. At grade-separated intersections, the following are taken into consideration: skew angle, traffic control, left and right turn lanes, and intersection sight distance. AMF continuously indicates the extent to which a deviation of an assumed basis value in the 'base model' leads to more or less crashes.

This approach, that for example is also used in Canada, is actually an attempt to make an estimate of the safety consequences of adjustments in the layout of our roads and their traffic in an integrated and quantitative way. Of course, the results of such models can never be transferred to another jurisdiction, meaning that every jurisdiction has to estimate its own parameter values.

### 2.2. Road safety engineering

Road safety engineering deals with prevention of crashes and the reduction of the severity of crashes by planning, design or traffic management. So, road safety engineering consists of two elements: safety conscious planning and safety conscious design. *Safety conscious planning* already deals with safety in the planning phase of new areas, new settlements, new roads and streets. Of extreme importance for road safety is how new road networks will be linked to the existing road network.

Another important safety aspect is the so-called access management (limitations!), referring to the entry of a roadway of traffic from other roads, roads to companies and other private properties (use of service roads).

*Safety conscious design* incorporates safety features in the design of new roads and streets, and the improvement of existing roads in such a way that 'preventable crashes' do not occur. The concept of 'preventable crashes' is based on three principles: apply effective measures, are beneficial to a society (in economic terms), and which fit in a vision (in order to create synergy between different interventions (Wegman, 2001).

Road safety engineering should build a solid base for other road safety activities, such as legislation and enforcement of that legislation. Especially speed limits and enforcement of these limits are crucial. Safety of cars and safety of roads should be complementary to each other.

### 2.3. Safety conscious planning

In the context of safety planning, *land use planning* can be described as the planning of the relative location of different types of land use and of the way they are connected. Land use planning deals with the spatial allocation of urban functions and the design of urban structures (Hummel, 2001c). The spatial organisation of land use types in an area determines: the number of generated trips, the modal choice, the length of trips and the route choice. The chosen urban structure determines: travel distances, the general road network design and the functional classification in a road network. So, land use planning can have a major influence on both mobility and safety. Important land use decisions with a possible influence on road crashes are: spatial allocation of origins and destinations, urban density, patterns of urban growth, general shape of the network, size of residential areas and provisions for the different transport modes.

If we accept the three dimensions of road safety (Rumar, 1999): exposure, crash risk and injury risk, *land use planning* could address all three. These safety principles are based on the 'Sustainable safety' vision, as described in paragraph 5:
- minimize exposure
    - promote efficient land use
    - provide efficient networks where the shortest routes coincide with the safest routes
    - promote alternative modes
- minimize crash risk
    - promote functionality, by preventing unintended use of each road
- minimize injury risk
    - reduce speeds

In the context of *route management* (Hummel, 2001b) the following safety principles are at stake:
- minimize exposure
    - provide efficient networks where the shortest/quickest routes coincide with the safest routs
- minimize crash risks
    - promote functionality, by preventing unintended use of each road
    - provide homogeneity, by preventing large differences in vehicle speed, mass, and direction of movement
    - provide predictability, thus preventing uncertainty amongst road users by enhancing the predictability of the road's course, and enabling the behaviour of other road users to be anticipated.

In the framework of *access management* (Hummel, 2001a) we are dealing with:
- minimize exposure
    - provide compact urban form
    - provide efficient networks
- minimize crash risks
    - the same provisions as in route management
- minimize injury risks

- reduce speeds

The influence of access management on road crashes is often overlooked. It is a very important item leading the Federal Highway Administration to the statement: 'One thing is very clear, the most important geometric design element in reducing crashes is access control' (FHWA, 1992).

In the literature, the foundation is to be found of the idea that land use planning is important for road safety. However, expressing the relations quantitatively is not possible. An important explanation for this is that the application of certain land use planning concepts does not, on their own, determine safety. The actual layout of roads and streets, and the behaviour of road users are always decisive. However, land use planning defines the conditions for the road designers, and they are thus determinant. If the safety effects of decisions in land use planning are considered in a very early stage of land use planning, developments can be directed in a safer direction. Deficiencies in the land use planning can cause unsafe structures and shapes. To prevent those deficiencies, road safety should be a major consideration in an early stage of land use planning, route management and access management.

A matter of a completely different order is how to apply these planning principles in existing urban structures. The principles remain valid but, the applications require much creativity, considerable budgets, and involve many compromises in making existing structure safer (IHT, 1990, OECD, 1990, DTLR, 1999, DUMAS, 1999).

A starting point of all safety activities in existing areas should be the functional road hierarchy or a categorization of road networks (SWOV, 1992). With the proper integration of land use and transportation planning, local roads and streets provide land access, while through traffic and high driving speeds are discouraged. On the other hand, the roads at the upper end of the hierarchy, such as arterials and motorways are planned to optimise traffic flow and speed, while severely restricting or eliminating all direct access to adjacent lands. Multi-functionality leads to contradictory design requirements and also to higher risk, as could be explained with the figures in Table 1. Combinations of functions, combined with use of different transport modes in the same physical space and relatively high speeds and speed differences lead to relatively high risks.

An example of a road categorization plan is giving in Figure 2

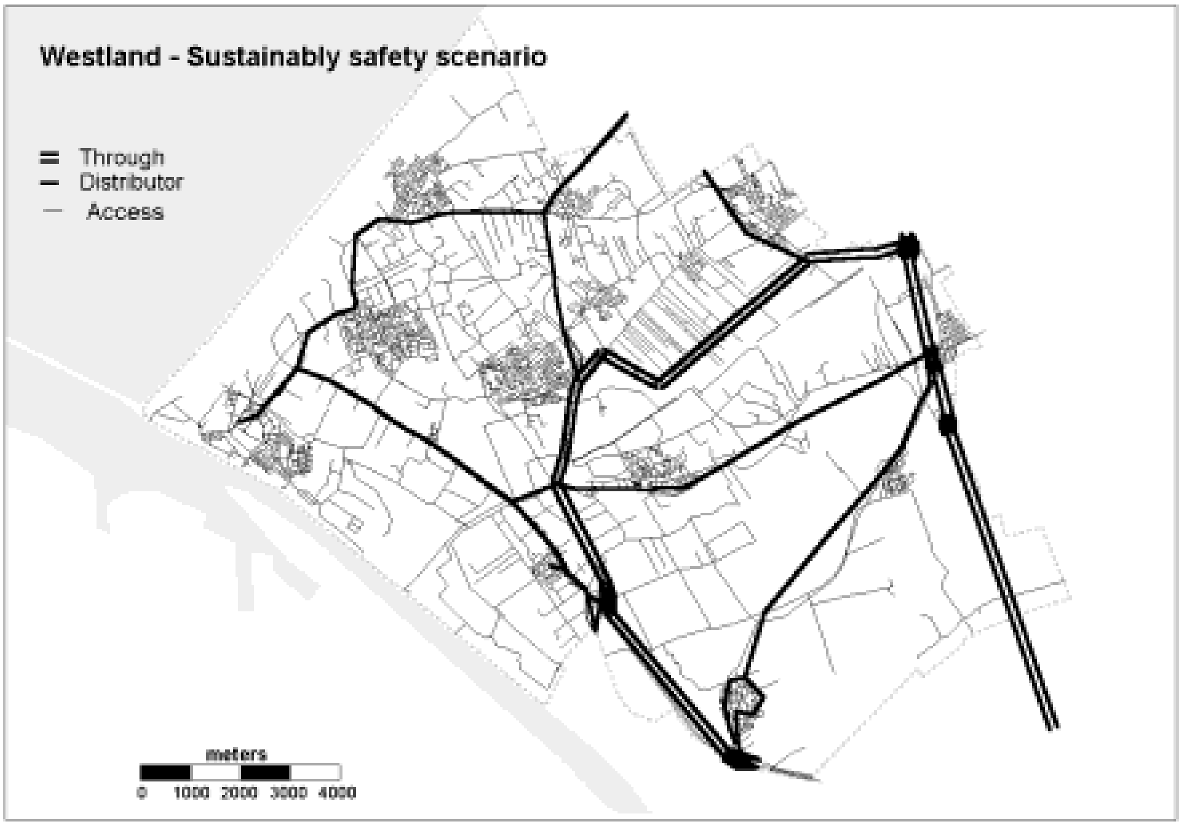


Figure 2. *Categorized road network: an example for an area in the Netherlands*

**2.4. Safety conscious design**

A categorized road network (based on mono-functionality) is a sound starting point for safe road design. Discrepancies between function, design and use lead to higher risks. Planners and designers have to create such an environment for the road users *that the design characteristics are consistent with the road's function and elicit the appropriate behaviour*. A second design adage should be: *design characteristics need to be consistent along a particular stretch of road*. Road design creates an expectation by road users as to the appropriate behaviour along a particular stretch of road. Since people are known to be relatively slow in adapting to a new situation, inconsistencies in design along the same road may easily lead to inappropriate behaviour and thus to errors.

However, these design philosophy and characteristics are not part of the normal design practices yet, and application of them in existing situations is a challenging task. An outline of road design practices is as follows. Roads are designed with several criteria in mind, such as travel time, comfort and convenience, safety, the environment, energy consumption, costs, and town and country planning. Some criteria are dealt with in qualitative terms, while quantitative norms are adopted for others. Most of the criteria mentioned interact: some combinations of criteria even produce conflicts. The art of designing a road is predominantly the art of giving the right weight to the various criteria, in order to find the most satisfactory solution.

Safety is usually one of the criteria that are taken into account as a matter of course: at every stage in the design process, the designer is expected to take decisions with safety in mind. But decisions are rarely taken for safety reasons alone. At the end of the process, therefore, it is difficult to judge the extent to which safety has been taken into account.

In general, safety can be considered at four levels (Ruyters et al., 1994):

1. Safety achieved through specific attention paid during the detailed road design process. However, road designers do not have always the right knowledge and awareness needed to give safety enough consideration.
2. Safety achieved through compliance with road design norms and standards. However, although standards, guidelines etc. are written with safety in mind, the authors almost never have quantitative knowledge of the link between engineering decisions and their safety consequences.
3. The level of safety than can be achieved through road classification. However, in practice, correct application of road classification has proved to be a major problem.
4. The (explicit) degree of safety offered by the conceptual transport system satisfying the need for mobility.

Road design standards play a vital role in road design, but major problems exist in this field: not all countries have road design standards for all types of roads, road authorities do not apply their own standards, some space for interpretation is possible, road safety arguments are treated fairly implicitly and – at least in Europe – there is no compatibility between the different countries. The non-availability and non-compatibility of road design standards for the road network in different countries increases risks and therefore contributes to the actual scale of the road safety problem.

It is good to observe an enormous increase of our knowledge in this field during the last decade. A good example is the attempt in Norway to draft a *Trafikksikkerhetshåndbok* (Road Safety Handbook), *The Traffic Safety Toolbox* by the Institute of Transportation Engineers (www.ite.org) and *A Road Safety Good Practice Guide* (DTLR, 2001). A very comprehensive and ambitious approach is the development of the *Interactive Highway Safety Design Model* (www.tfhrc.gov), by the Turner-Fairbank Highway Research Centre from the Federal Highway Administration in the United States. This model consists of several modules (crash prediction module, design consistency module, intersection review module, policy review module, traffic analysis module). All these modules are part of the 2003 release. One module is still under development: the driver/vehicle module. This has turned out be a complex and complicated module, leading us to a second problem, to be mentioned here.

Design standards are traditionally based on 'basic assumptions' regarding, for example, reaction times, eye heights, friction coefficients between tyres and the road surface, deceleration and acceleration of vehicles, etc. On the basis of assumptions on these factors and the choice of the design speed, the stopping distances, sight distances, overtaking distances, lane width, bend curvature etc. can be calculated and incorporated in the design guidelines.

But we have to admit that we still face a major problem in talking about safety on our roads. Traffic engineers and road designers do not know exactly how and why road users behave as they do, and how they could influence behaviour through design. Behavioural scientists and engineers need to work together more closely to improve understanding of road behaviour and to change it in the right directions. Both in Europe (van der Horst & Hagenzieker, 2002) as in the United States (NCHRP-project 17-18/31 on: www.trb.org) a growing interest can be observed for developing Human Factor Guidelines for road systems.

## 3. Assessment of the safety quality of a road network and roads and streets

### 3.1. Procedures to assess safety quality of existing roads

Traditionally, there are two methods of determining the safety quality of roads: the black spot approach and the road safety inspections. In the so-called *black spot* approach, parts of the road network are selected (mainly intersections) in which, in the past, there was a concentration of crashes. Although no international agreement seems to have been made about the definition, the concept is mainly the same: a selection of locations, a diagnosis of the crashes that have occurred in order to establish accident patterns, a selection of the appropriate measures, and then an evaluation of the measures taken. Their usefulness in reducing the number of crashes has been queried the last years. If the approach had been successful, it would have become a victim of its own success: after all, no black spots would have remained. But, there is even doubt about that. Elvik (1997) published an article in which the conclusion has been drawn that there has been no statistically significant effect of the black spot approach. A problem with evaluation studies of improvements emanating from black spot treatments is, that there hasn't always been a control for 'confounding factors', such as regression-to-the-mean and accident migration. A plausible explanation for this unexpected effect hasn't anyway been given yet. Neither, since the Elvik results, has any other study been presented that places matters in another perspective.

There are still two questions to be answered. First of all, there is the question of whether registered crashes in the past are still good predictors for those in the future. With such a question as starting point, the *SafetyAnalyst* programme (www.safetyanalyst.org) has chosen a combination of safety performance functions (SPF) and the application of the so-called Empirical Bayes (EB) method (FHWA, 2002). This method combines two sources of information: the expected number of accidents, estimated by means of a safety performance function and the registered number of accidents. Another example of this approach (based on crashes in the past) is an approach in which a 'standardized number of crashes' is determined for a road type, with which individual roads will be compared. If, on a road, more crashes occur (than the norm), then there is reason for action. This approach is the basis idea behind the EuroRAP programme (Lynam et al., 2003). The idea behind this is that a greater number of accidents than the 'norm' will appear to be interesting for crash reduction activities.

A second comment on the black spot approach has emerged from efficiency considerations: we are not actually interested in a screening of the roads for unsafety in the past, but for improvement possibilities in the future. That is why, in the SafetyAnalyst programme, the concept of 'sites with promise' will be introduced, based on cost-effectiveness considerations.

Another example of this approach (based on crashes in the past) is an approach in which a 'standardized number of crashes' is determined for a road type, with which individual roads will be compared. If, on a road, more crashes occur (than the norm), then there is reason for action. This approach is the basis idea behind the EuroRAP programme (Lynam et al., 2003). The idea behind this is that a greater number of accidents than the 'norm' will appear to be interesting for crash reduction activities.

At this moment in time, it cannot be exactly predicted what the possibilities will be for the various methods being currently developed. But it is certain that, in comparison with the traditional black spot approach, improvements are necessary and seem possible.

A second method can be summarized as (visual) *road safety inspections*. Here also, traditionally many possible implementation forms have been applied. There are many simple implementation forms in which personnel of the road authority drive around, make a note of striking matters, and often immediately take simple measures. There are also more advanced methods in which, for example, use is made of a video. This leads, in the EuroRAP programme to a 'Road Protection Score' (Lynam et al., 2003). Little has been reported about the effectiveness of such inspections, in terms of accident reduction. In this context is the attempt being carried out in New Zealand to reach a more objective methodology (Wilkie, n.a.). In his article, Wilkie claims to have found a correlation between the results of the ratings of a 'quantitative method of assessment' and the accident history of a particular stretch of road. A further exploration of such methods is highly recommended because the methods are relatively simple, which is why they are attractive for a road authority and, if they are effective, they are nearly always cost-effective.

Apart from the methods mentioned here, there are ways of working that attempt to establish the extent in which the actual road design differs from that which has been agreed upon in the design guidelines, or what is considered a desirable and safe design. The IHSDM program contains a module, the Policy Review Module, in which can rapidly be determined if a road (or road design) differs from that in the so-called Green Book of the American Association of State Highway and Transportation Officials (AASHTO). An attempt is being made in the Netherlands to develop an instrument for determining the sustainably safe character of existing roads and new designs (Dijkstra, 2003).

To summarize, it can be concluded that, during recent years, one can talk about a revision in thinking about the approach of the safety screening of roads; this development can certainly be called promising.

### 3.2. Safety quality of new designs

Several definitions are used to describe techniques to assess the safety quality of new road designs. It is helpful to distinguish two phases. A *road safety impact assessment* (RIA) is a formal procedure for independent assessment of the likely effects of proposed road or traffic schemes ('variants'), or indeed other schemes (e.g. changing speed limits) that have substantial effects on road traffic, upon accident occurrence throughout the road network upon which traffic conditions may be affected by the schemes (ETSC, 1997). A *road safety audit* (RSA) is a formal procedure for independent assessment of the accident potential and likely safety performance of a specific design for a road or traffic scheme – whether new construction or an alteration to an existing road. The aim is similar and the difference is the scope and timing. The scope of a RSA is usually confined to an individual road scheme. A RIA covers a larger part of the road network than the scheme itself. A RIA precedes and complements the eventual RSA or RSA's. For smaller schemes, the two procedures can be combined by extending the first phase of a RSA (feasibility stage) to include the likely effects of the scheme on accident occurrence in the surrounding network. The aim of a RIA is to take better-informed decisions on a strategic level, in which the road safety impact has been made transparent for the political decision makers. A RIA could go parallel in time with other impact assessments (for example a Strategic Environmental Impact Assessment). A RSA aids to make a safer road design and may affect the scheme site and/or the nearby network. A RSA result is used most of the time by the management of a road authority.

A *Road Safety Impact Assessment (RIA)* procedure tries to include in a quantitative way the safety consequences of changes of traffic over a road network due to infrastructural projects (new roads, new road lay outs, etc.) or a major change in general operating conditions by using a scenario technique (Wegman et al, 1994). This technique uses the fact that different categories of roads (with different road and traffic characteristics) have different road safety records dependent on traffic volumes. This relationship between traffic volumes and crash risks are known as Safety Performance Functions. Added to or included in these models are the so-called accident modification factors in which the safety effects of different road characteristics are modelled. The results of a RIA shall be considered in the planning process alongside other information relevant to the decision-making on which of the variants shall be selected.

The *Road Safety Audits (RSA)* process is designed to pro-actively improve road safety through formal independent review of designs for constructing new roads, for traffic operation plans and also for modifying existing roads. The essential elements are: a formal and independent process, carried out by an expert ('trained auditor'), restricted to road safety issues. Many audit procedures distinguishes five stages: feasibility, draft design, detailed design, pre-opening and in-service. Auditors (or a team of auditors) in many cases use checklists or prompts. Checklists are available from all over the world.

How to establish the effectiveness of applying RIA or RSA? The aim of a RIA is not necessarily to reduce the number of casualties. The aim is to take 'informed decisions' and to weigh quantitatively road safety information to other important aspects in a scorecard. So, decision makers have to profit from a RIA-result and the quality of the decision-making process should be qualified as better with the RIA-results than without them.

Then, what is the effectiveness of a RSA? In general, the literature suggests that RSA process is effective and cost-effective (safer roads, better and more transparent design practices, enhancement of road safety engineering, better informed decision-makers, reduced need for remedial work after new schemes are built, etc). However, the studies were not very convincing, dividing the world in ‘believers’ and ‘non-believers’. A convincing approach on establishing RSA-benefits has been issued in Australia just recently (Macauly & McInerney, 2002). The development of their method was based on the so-called Safety Risk Manager. That tool allows an assessment of the risk of a wide range of hazards and their associated treatments. This method has been applied in a limited amount of design stage audits. The results are very encouraging (in almost all cases Benefit-cost ratios > 1.0) and the majority of audit findings in this pilot required only very low-cost responses. Austroads concludes ‘that the findings confirm the current belief that the audit process is a valuable and beneficial process in maximising the safety of the road network and minimising road trauma’.

## 4. Safety effects of improving roads

### 4.1. Rural roads

Each year, about 60% of all fatalities in OECD Member countries are on rural roads, and this share has increased over the last decades (OECD, 1999). As much of 80% of all crashes on rural roads falls into three categories: single vehicle crashes, especially running of the roads (35%), head-on collisions (25%) and collisions at intersections (20%). Driver behaviour and road infrastructure are the key contributing factors to these types of crashes. Rural crashes are scattered over the entire rural road network. The rural road system itself has inherent characteristics that significantly contribute to the high number of crashes and the high risks, according to the OECD-report. Inappropriate and excessive speeds are a key factor in rural road crashes because the actual speeds on rural roads are relatively high under circumstances where these high speeds cannot be safely maintained. Rural roads require constant speed adaptation to the regularly changing situations and circumstances, thus increasing the opportunities for human errors and leading to higher risks for crashes. The OECD-report therefore concludes that reducing inappropriate and excessive speed together with safe road design and roadside design are the key elements to improve rural road safety (aside from this, fatigue and alcohol/drug use are also key factors in rural safety). Equally important, speed variation caused by the presence of buses, heavy trucks agricultural vehicles, mopeds and bicyclists generate higher crash risks than on other types of roads.

The main type of rural road crash occurs most often in horizontal curves rather than on adjacent tangent sections. Design consistency seems to be the key concept to address this problem (Lamm et al., 1999). See also the Design Consistency Module in IHSDM (www.tfhrsc.gov). Flattening horizontal curves is an effective, but expensive crash-reduction measure, only cost-effective on higher-volume roads. Less expensive measures are therefore recommended, such as removing (or protecting road users from) roadside hazards, flattening side slopes, improvement skid resistance, increasing the super-elevation, paving the shoulders and eliminating pavement edge-drops. As low-cost measures could be considered (upgrading edge and centre line, adding reflective markers or upgrading the advance warning. Rumble devices can also be effective, as could be roadside markings. However, a Finnish study (Kallberg, 1991) found that care must be taken not to provide too much visual guidance on roads with relatively low design standards as it may lead to speeds, which are inappropriate for the road.

Forgiving roadside concepts and roadside improvements in general can significantly reduce the severity of crashes, there is a very high potential for improving overall safety by treating or removing roadside obstacles (Ogden, 1996, OECD, 1999).

In relation to head-on crashes, prevention can be accomplished by physically separating opposing traffic with soft and hard solutions. Physical space in a cross-section is needed. A rather drastic approach that is accomplishable on rural roads is narrow physical separation by means of double centre lines, double centre lines with physical features glued to the surface, or by harder physical means such as kerbstones, cable barriers, guardrails or concrete barriers. These physical barriers could have influence on traffic operations (emergency services, surface maintenance, winter maintenance). In order to cater for overtaking conflict-free overtaking opportunities could be created for regular overtaking lanes. The so-called '2 + 1-concept' in Germany turns out to be a relative safe solution (Palm & Schmidt, 1999). Another opportunity is a combination of an increasing lane width and shoulder width, allowing for overtaking not crossing the centre-line ('the Swedish solution').

In considering intersection collision, roundabouts have a very good safety record in comparison to three- and four-way intersections  If such a solution is not cost-effective or is waiting for reconstruction-activities, channelization could be considered.

In addressing the issue the issue of speed variance, separating slow and fast traffic will contribute to the overall safety of rural roads. For the Netherlands for example, this means separated facilities for cyclists/mopeds and for agricultural vehicles.

### 4.2. Urban areas including traffic calming

The proportion of fatal road crashes in urban areas varies from 15% to almost 50% in OECD countries (OECD, 2002). Between half and three-quarters of all injury crashes occur in urban areas. Road crashes in urban areas are often scattered randomly in an area, besides those crashes concentrated at 'black spots'. To illustrate this: about 75% of all crashes occur on traffic arteries, which form 25% of the road length in urban areas in the Netherlands. The other 25% occur in residential streets, scattered all over the area. Our vulnerable road users such as pedestrians, cyclists, young and older road users meet key-problems. This is the result of a complex mix of factors (ETSC, 1999)  but underlying all other problems is the fact that the modern traffic system in our metropolitan areas, cities and villages has its origin in history and was not designed for modern traffic. Furthermore, adaptation of our roads and streets to more and more cars and traffic has been done mainly from a car-user perspective. The struggle between cities and cars started in many countries already in the 1950s and 1960s. Jane Jacobs and Colin Buchanan, the Radburn-principle, the SCAFT-guidelines are the eye-catching names to address the problems of the dominant position of motorized car traffic and the problems related to that at a very early stage. Road crashes were not seen as the dominant problem. It was the struggle between an efficient road traffic system and the liveability of the citizens in cities and villages. In the 1970s road crashes started to be considered as a problem, in close connection with liveability and amenity. Two answers were formulated to make our streets and roads in urban areas safer: more separation of different traffic modes (as was applied successfully in new areas) and integration (OECD, 1979). It soon became clear that from a road safety point of view, traffic calming in residential areas had to be area-wide rather than applying it to an individual street only. Low traffic volumes and a low density of traffic violations make police enforcement inefficient. Physical speed reducing measures were introduced to support a speed limit of 30 km/h.

Nowadays a more general term is used: traffic calming. Application of this principle started in residential streets, but these days we use the same ideas to make main traffic arteries safer. Traffic calming on traffic arteries aims at an appropriate speed for motorized traffic and to provide safe and attractive facilities for the vulnerable and soft transport modes.

In two large-scale pilot projects in the Dutch cities of Rijswijk and Eindhoven it was found that traffic calming indeed substantially reduced the number of injury accidents, not only in the 'woonerf' areas (homezones), but also in 30 km/h-zones. The reduction percentage reported were about 25%, and this same figure was also found in a recent meta-analysis on the effects of speed reducing measures in residential streets (Elvik, 2001). We have enough knowledge and expertise to design safe residential areas and to redesign existing residential areas (van Schagen, 2003). We have experiences from all over the world: Tempo-30 zones in Germany, 'silent roads' in Denmark, etc. From the 'human tolerance' perspective we learned that collision speeds between cars and vulnerable road users have to be lower than 30 km/h. And because the implementation of 'woonerfs' was costly and not more effective than 30 km/h-zones, it was decided just to implement 30 km/h-zones. In the beginning the size of the 30 km-schemes was limited. Later, due to the wish of local road authorities to reduce investment costs, traffic calming measures were only required when entering a 30 km/h-zone, at intersections, and at sites that are considered risky (in front of a school for example). In the Netherlands between 1985 and 1997, 10-15% of the urban residential, roads were converted to 30 km/h-zones (Koornstra et al., 2002). The average saving of accidents in these zones is quoted as about 40%. Between 1997 and 2002 ( 5 years) the proportion of roads converted has increased to 50%. These last 5 years, the 30 km/h-treatments are not that comprehensive as in the period before. The interesting observation can be made that traffic calming is not an incidental treatment anymore, but all Dutch local authorities do implement these schemes and their character is more and more low-cost (in order to increase the treated road length). At the same time, the gradually growing length of cycle facilities and the increase of the number of roundabouts have accomplished a substantial improvement of safety. Roundabouts are the safest type of intersection in the Netherlands and their amount is growing every year. SWOV estimated a crash reduction of up to 70% is possible compared with the traditional 4-leg intersection.

As years passed by, the scope and considerations with respect to traffic calming broadened, emphasising urban-wide measures to reduce motorised traffic and to promote other transport modes. Urban safety management comprises a wide variety of interventions and measures (e.g. IHT, 1990, DUMAS, 2001). However, implementation of these interventions seems not to be taken on a large scale. The knowledge is there, pilot projects have been carried out. A further analysis of this lack of progress is appropriate. Integration with other policy fields in order to reach other goals as well, with the same interventions should be considered. It can be concluded from the Dutch experiences that to create a so-called 'delivery mechanism' for urban safety management, the role of local politicians and of public participation could not easily be overestimated (van Schagen, 2003).

## 5. New paradigm to further reduce road crashes

### 5.1. Introduction

In the history of road safety policy, different accents have been based on different paradigms over the years (OECD, 1997). In a SWOV-report (Mulder & Wegman, 1999), the sequence of policy accents is described; they evidently follow a pattern (SWOV, 1992). Early in the 1990s, SWOV was asked the question as to how road traffic in the Netherlands could be considerably safer: not 1000 deaths a year, but not more than 100 a year. Two lines were open. According to the first line, a considerable improvement had to be achieved by conducting the current improvement activities 'more and better'. The second line was that such an improvement would be achieved by adopting the vision that safety should also be a design principle for the road traffic system (as was for other transport systems). In the end, the conclusion was that the first line could lead to considerable improvements, but that additional ideas would be necessary to make the road traffic considerably safer. This originally lead to the idea of an 'inherently safe road traffic' (based on ideas from the energy production and distribution). In order to obtain sufficient public support, the vision was renamed 'sustainably safe'. The *Sustainable Safe vision* is based on two leading ideas, as explained in paragraph 1: how do people try to prevent errors as much as possible and how to ensure that the collision conditions are such that the human tolerance is not exceeded and severe injury is practically excluded.

### 5.2. Sustainable safety: the vision

The aim of 'sustainable safety' is not present a burden for future generations of the road crashes consequences of today's and future mobility demands given that means are available to reduce substantially the costly and largely avoidable road casualty problem. From this perspective, it was chosen to 'borrow' from the well-known Brundtland-report on sustainable development, the adjective sustainable for safety as well: *no longer do we want to hand over a road traffic system to the next generation in which we tolerate that road transport inevitably leads to thousands of killed people and ten thousands of injured in the Netherlands, every year.* So, the starting point of 'sustainable safety' is to drastically reduce the probability of crashes in advance by means of infrastructural design. In addition, where crashes still occur, the process that determines the severity of these crashes should be influenced, so that serious injury is virtually excluded.

The concept is based on the principle that 'man is the reference standard' (human error and human tolerance). A sustainable safe traffic system has an infrastructure that is adapted to the limitations of human capacity, through proper road design, vehicles equipped with tools to simplify the tasks of man and constructed to protect the vulnerable human being (crash protection) as effectively as possible, and a road user who is adequately educated, informed and, where necessary, controlled.

The key to arrive at a sustainable safe traffic system lies in the systematic and consistent application of three safety principles:
- functional use of the road network by preventing unintended use of roads;
- homogeneous use by preventing large discrepancies in speed, direction and mass ad moderate and high speeds;
- predictable use, thus preventing uncertainties amongst road users, by enhancing the predictability of the course of the road and the behaviour of other road users.

As stated before, the road user as the reference standard represents the central element in a sustainable safe traffic system. He/she must be prepared to accept an infrastructure, vehicles, and rules of behaviour, information and control systems, which may restrict his/her personal freedom, in return for a higher level of safety. If this willingness is not present, resistance will be the result. Freedom restrictions without good arguments should not be offered to the road users. Social marketing techniques could be used here.

The three safety principles (functional use, homogeneous use, and predictable use) require the specification of the intended traffic function of each road and street. Roads should perform one of the three major traffic functions:
- the flow function: enabling high speeds of long distance traffic and, often, high volumes;
- the distributor function: serving districts and regions containing scattered destinations;
- the access function: enabling direct access to properties alongside a road or street.
Besides a traffic function, streets and roads in built-up areas should allow people to stay in the vicinity of their house safely and comfortably. This so-called residential function could well be combined with the access function.

Education could and should play an important role in the transition period from the traffic system of today to a sustainably safe system. Education could concentrate on the whys and wherefores of sustainable safety. Public awareness, public participation and education should create support for implementation and find their place alongside implementation of other key elements of this vision. Without any doubt we shall need in the transition period as in the sustainable safe period education to learn and to motivate people to use the system safely and to deter of undesirable and dangerous behaviour by organising an effective 'deterrent chain' (police enforcement and punishment).

With respect to vehicles, the diversity of vehicles should be kept to a minimum. Furthermore, the various types should be clearly distinguished. When used in the same 'physical space', vehicles should demonstrate the same behaviour – in all respects – or otherwise be provided with separate road facilities. In the sphere of passive sustainable safety provisions lay those that work independently of the driver or passenger: 'built-in' devices like solid passenger compartments of cars with crushable zones and airbags (in addition to the compulsory use of seat belts). Improvements of the front-end design of passenger cars, to reduce injuries to vulnerable road users like pedestrians and cyclists, are relevant as well. In the field of active safety a lot of progress may be expected from devices, which provide relevant information to the road users, improve their observation, or simplify their tasks. An interesting development is the so-called Intelligent Speed Adapter (ISA). Two real problems have to be solved here: gaining public acceptance and support, and developing an introduction strategy.

### 5.3. Sustainable safety: the implementation

The sustainable safety vision was conceived in the early 1990s. The consistent application of the three principles (functional, homogeneous and predictable use) requires the support and commitment of all stakeholders (all tiers of government, all road authorities and of the road safety community) to implement measures in a coordinated manner. I order to create such a partnership, the key stakeholders had to be involved in developing the vision and its implementation. Furthermore, it has to be understood that large amounts of funding were needed to adapt the Dutch road network to the sustainable safety principles. From the beginning, it was clear that not road safety budgets, but road budgets have to be made available in order to come to full implementation. SWOV-estimates indicated that an annual return of investment of 9 percent could be expected, which represents twice the usual 4 returns from large infrastructure projects (Poppe & Muizelaar, 1996).

Road authorities at all three levels (national, regional, and local) came to an agreement for a so-called 'Start-up programme', covering the period 1997-2002. The central government provided about €240 million, as a grant, about half of the costs. Later, it became clear that regional and local authorities provided a far higher amount of money. SWOV estimated that the regional and the local level invested something in between € 200 and € 250 million a year in improving road safety.

We have strong indications that these investments resulted in a reduction of number of people killed and injured in Dutch traffic. The formal monitoring and evaluation has not been published yet.

The process leading to full support of key-stakeholders has been described in other papers (Wegman & Wouters, 2002). From the introduction process, specific lessons could be learned to be at least supportive of, or were even a prerequisite for successful action:

- The conviction that the current policy was not sufficiently effective in reaching the road safety targets in the Netherlands. Thus something 'new' was needed.
- Road safety experts and the professional world should express themselves in full accordance with the new concept. If experts disagree, policy makers and politicians will feel uncertain and decisions might be postponed.
- The vision has to appeal in both the short term and the long term. Of course, no concept is drawn up for eternity.
- From the start, the vision has to enhance creativity and not resistance. An important element with respect to this: appealing directions and no obvious drawbacks.
- Road safety organisations and lobby groups (stakeholders and 'actors') have to consider the vision as offering them new opportunities.
- Implementation of the vision must be integrated in existing budget streams.
- Structural opportunities to connect the vision to other activities should be looked for and created: drafting guidelines for road design, education curricula for schools, etc.
- Last but not least: intelligent ways to commit stakeholders have to be found.

Sustainable safety is the cornerstone of Dutch road safety policies and forms an integral part of Dutch transport and traffic policies. The Dutch Government is drafting a new policy document on this and discussion on this policy document in Dutch Parliament is expected to take place 2004, if not later. In the meantime two further developments can be observed. Based on the successful action strategy in the past, prolonging the good and effective partnerships between the different tiers of government when it comes to implementation of sustainable safety (until 2010). The second development is to design the *Next Generation of Sustainable Safety.*

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# Human errors and traffic safety

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This paper will present a bottom up perspective on road traffic. Traffic safety is described with the individual accident and the characteristics of the individual road user in focus. This perspective is important as a compliment to the perhaps more powerful top down descriptions as it can offer an understanding of the road user that could help us to find new measures to improve the traffic situation.

Road user behavior is the key to traffic safety. It's almost a definition of an accident that it involves some type of a human error. The road user could be said to be the week link in the road traffic system. On the other had mans tremendous adaptive skill is the most important factor explaining why the road traffic system is rather safe after all. Just imagine what would happen when a traffic signal broke down if the drivers wouldn't be able to adapt to the situation.

In principle we have three methods to control road user behavior: selection of road users, education of road users and adjust the technical part of the system to the road users capacity.

To use tests to try to select those drivers that would be expected to be involved in accidents in the future, in order to prevent them from driving, has of course its background in the idea that some people are more accident-prone than others. This very popular theory has two problems though, which makes it difficult to use. First when we control for differences in experience and exposure there is a rather small variance in accident risk among drivers left. Secondly the precision of the selective tests, that could be used, are so poor that it would be necessary, in order to get any effect of the selection, to prevent so many people from driving that it wouldn't be acceptable. After all it's so important to be able to use a privet car in a modern society that the availability of a driver's license can almost be seen as a human right. The only selection that is made today, at lest in Sweden, to prevent some people from driving is dependent on serious criminality, severe traffic offences like drinking and driving and exceeding the speed limits by more then 30 km/h and different types of disorders.

In contrast to selection education probably is a very important and undervalued method to improve traffic safety. The reason that it has been undervalued is probably because it has been very difficult to show any substantial effects of road user education. A possible reason fore this is that the methods of education or of evaluating the effect of the education are too poor. But it's hardly reasonably to believe that road user behavior would be one of the very few human activities where education wouldn't be effective.

The high accident risk we can see among young drivers all over the world is a challenge to everybody working with driver education. There has been a development during the last years concerning driver education that give some evidence that the following elements could give safety benefits (Engström et al. 2003):

- Introduction of a second phase including training and minimal restrictions
- Increased training under protected conditions
- Shift of contents in training: from mastery of vehicle and traffic situations towards driving motives, risky behaviour, hazard perception, large safety margins and self-assessment (in accordance with the GDE-matrix (Goals for Driver Education) Hatakka et al. 2002)
- Increased experience through layman-accompanied driving
- Integration of improved measures (professional training, accompanied driving, phasing the training, development of examination etc.)

Engström et al.(2003) especially points on the following trends of driver education in Europe:

- Extending the accompanied pre-test driving period
  - more layman instruction
  - lower minimal practicing age
- Multiphase systems are introduced or planned in about 8 countries
- Shift of contents in training: from mastery of vehicle and traffic situations towards driving motives, risky behaviour, hazard perception, large safety margins and self-assessment (in accordance with the GDE-matrix (Goals for Driver Education))
- Compact professional training to prepare candidates to accompanied training
- Integration of demerit point systems and driver improvement programs into driver licensing systems
- Awareness of lack in development of driving test according to new contents in training

When we talk about influencing human behavior we mainly think of pedagogical methods or methods of mass communication to change the attitude of people like advertising and commercials. We often forget the perhaps most important factor influencing human behavior, the preconditions for behavior that the physical surroundings offer. After all if there isn't any goods to buy or money to pay with we will not see any consumer behavior regardless of any advertising efforts. The round about has shown to be a very efficient way of monitoring road user behaviour by the design of the road environment. Brûde and Larsson (2003) have shown the round about to be one of the safest types of crossings even safer than signalized and grade separated intersections.

The Danish researcher Jens Rasmusen has presented a model describing how an operator in a technical system controls his behavior in relation to the condition the system offers (Rasmusen 1986). The model is very general why it's possible to use it as a description of how the road user control his behavior in relation to the technical preconditions the vehicles and the road environment offers. Rasmusen is talking about three control levels. Knowledge based, rule based and skill based control. (See figure 1.)

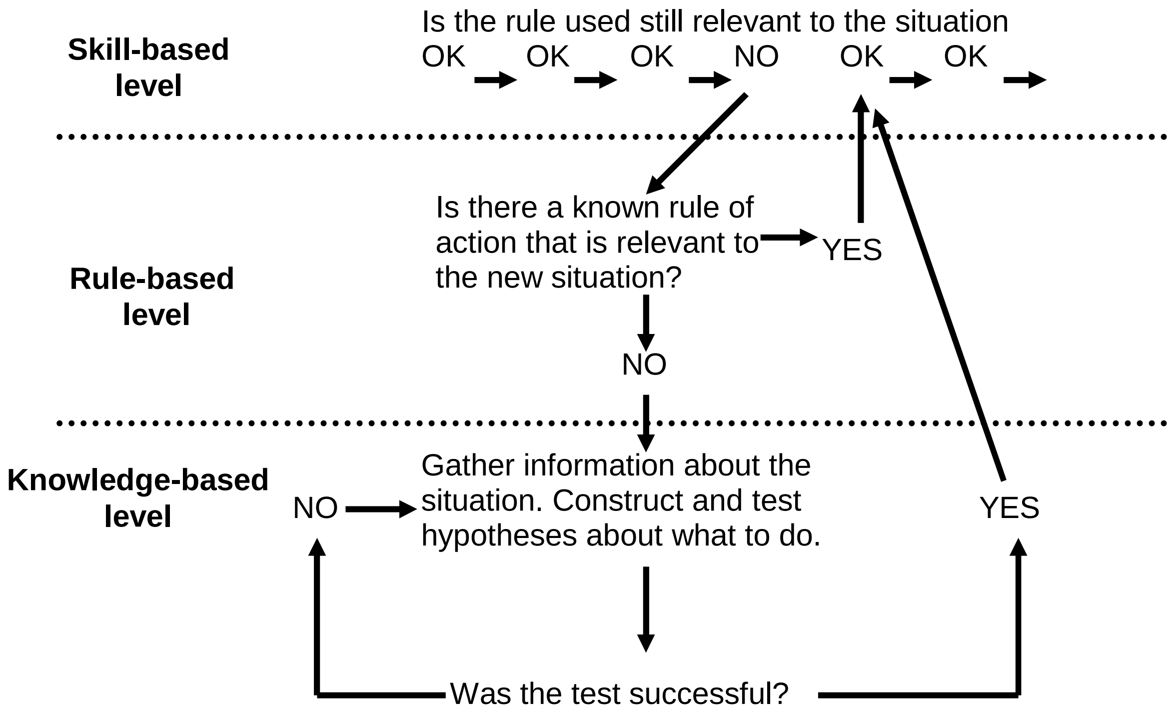


Figure 1. A three level model of an operator's control of his behavior in a man machine system. Freely after Rasmusen (1986).

Knowledge based control has to be used in new situations of which the road user has non or very little experience. In these situations it's necessary to gather information about the conditions the situation offers and to make up hypotheses about what actions to take. This type of control could be seen as a kind of problem solving and the behavior often have the character of trial and error. Knowledge based control is time and attention consuming and therefore not suitable to be used to control tactical and operative behavior by active road users. Hopefully at least car drivers have so much knowledge of traffic before they start driving on their own that they haven't to deal with the situation as a problem solving situation. But concerning more strategic road user behavior as trip planning, buying vehicles or other decisions of importance to the conditions of the traveling it is of course good to make use of knowledge based control.

The more experience a person gets of a situation the less information he got to gather in order to know what actions to take. He will recognize the situation without analyzing the details and he creates a rule saying how to act in this situation. This means that immediately when he recognizes the situation he knows what actions too take. He executes ruled based control of his behavior. As the control only involves recognizing situations and a choice among a limited number of action rules this control is rather quick and not so attention demanding. This type of control is therefore suitable for controlling the tactical task of road user behavior. That is the decisions the road user makes as he's actually traveling. Examples of tactical driver behavior is decisions about what speed to choose, whether to overtake or not, where to look for crucial information and so on. An important part of the road user education is to help the road user to create safe and efficient action rules. There is god reason to believe that the formation of action rules isn't an intellectual task but rather the result of skill training. This means that driver training isn't some thing that should be done in a very compressed time. We have in Sweden had very god experience of a system where we allow young people to start training car driving with there parents from their sixteenth birthday all thought they will not be allowed to take there driving license examine before they are eighteen.

The third of Rasmusens control levels is called the skill-based control level and is actually the execution of the rules chosen at the rule-based level. This control is very fast and demands very little attention. Skilled-based controlled behavior could be said to be automatic and controlled on an unconscious level. An example of behavior that is controlled at this level is the handling of the controls of the vehicle. Of course it's important that for instance the driver get such training that he manages the operative control of his vehicle on a skilled-based level. Actually I don't think this is a big problem in contrast to the rule-based control where education certainly needs improvements.

A general conclusion that could be drawn from Jens Rasmusens model about the design of the technical part of the road traffic system is that standardization is important. In other words it's important to design the technical part of the system in such a way that the road users easily recognize the situations so that they can choose the correct action rules.

What about human errors? What happens when the road users doesn't manage to control their behavior in a correct way? The British psychologist James Reason has formulated a model of human error partly based on Rasmusens theory (Reason, 1990). Reasons definition of a human error is that the acting person didn't succeed in reaching the intention of his action. In relation to Rasmusen this gives us three main types of errors corresponding to the three different levels of behavioral control slips or lapse at the skill-based level, rule-based mistakes and knowledge-based mistakes (see fig.2)

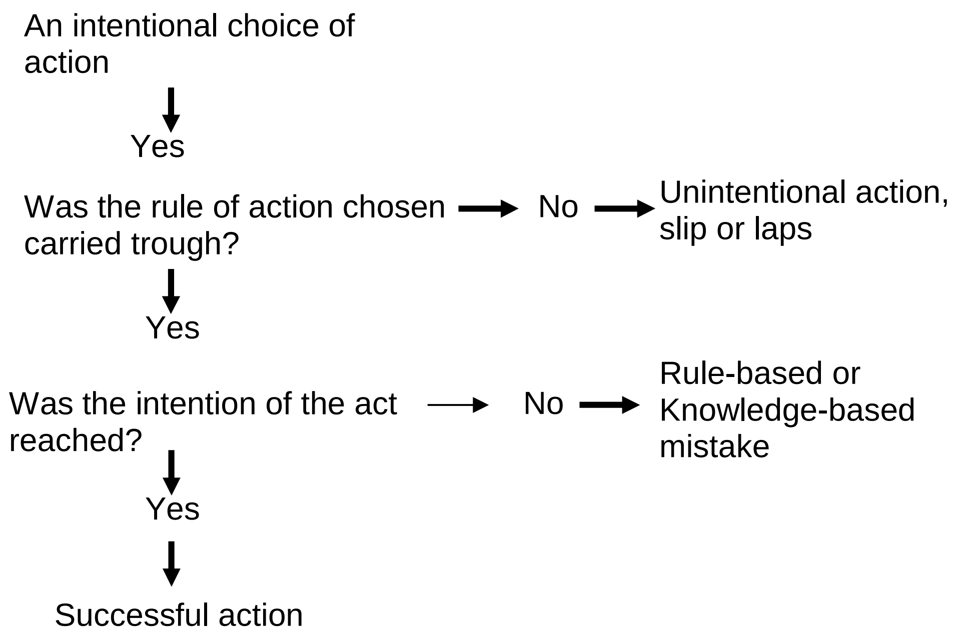


Figure 2. Classification of human errors. Freely after Reason 1990.

Imagine a situation where the road user has chosen the correct rule of action but he doesn't mange to act according to the rule. The reason fore this is always some disturbance of the road user's attention and results in an error on the skilled based level. Reason calls these types of errors slips and laps. As an example let's look at an accident which actually has happed and which is illustrated in figure 3.

The lorry driver is very familiar with the situation, as he has been passing the crossing several times every weekday for the last two years. He is therefore aware of the problem with cars sneaking up on the right side of his vehicle as he has to leave so much space on that side in order to make the right turn with his voluminous vehicle possible. It's reasonable to think that the lorry driver in this situation has a rule of action saying some thing like "*look right to make sure there isn't any vehicle on your right side, turn on your right flasher, look left to make sure that there isn't any conflicting traffic coming from that side, finally check the right side again before starting the turning maneuver*". What went wrong? When the driver looks left he discovers a vehicle coming from that side. As he is in a hurry, to be able to unload his cargo before the staff on his destination would take lunch, he decides to make his right turn before the vehicle from the left reaches the crossing. In his eagerness he "forgets" to make the last right hand check.

Attention misses like this is really a part of human nature, the price we pay for our flexibility. And naturally education isn't effective to minimize this type of errors. A recommendation is of course to design the traffic environment in such a way that the distraction and the optional actions of the road users are minimized. But as long as we won't turn the road traffic system into an automatic system almost independent of the road users we will see errors like this and they are common. This points on the importance of passive safety or injury preventive measures, which although it isn't the subject of this paper, it's important to point out as a necessary part of an effective traffic safety strategy.

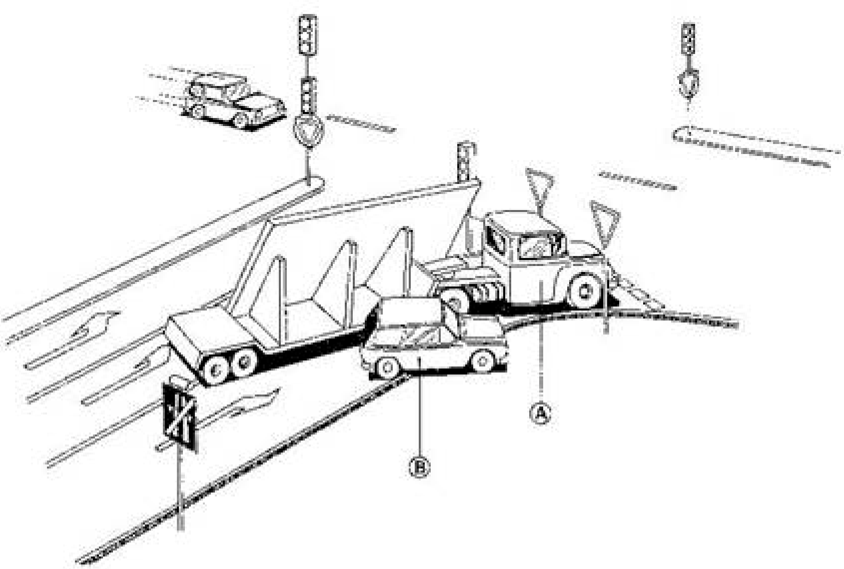


Figure 3. Example accident 1.

A very different type of human errors is what Reason calls rule-based mistakes. In this case the road user has managed to act according to the rule. The problem is that the rule doesn't lead to the purpose or the goal of the action, i.e. it's the wrong rule. As an example let's look at still an other accident which actually has happed and which is illustrated in figure 4.

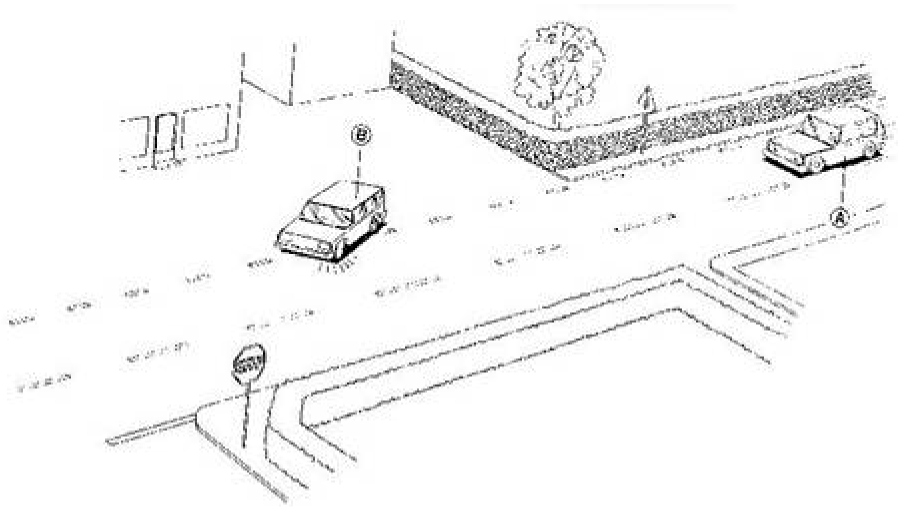

Figure 4. Example accident 2.

Figure 4 shows vehicle B standing on a parking area in front of a shop. The parking area is separated from the road only by a painted white line. The intention of the driver of vehicle B is to enter the road and therefore he turns on his left flasher. The driver of vehicle A is traveling on the road in a southern direction. The two vehicles collide on the left side of the road seen from the view of driver A.

The driver of vehicle A sees vehicle B with its left flasher on. This makes him believe that driver B intend to enter the road and travel on in the same direction has he himself. As there is no oncoming traffic he shifts to the left part of the road to let B enter the road and allow him self to overtake vehicle B in a safe way. As you certainly have understood driver A has misinterpreted the intention of driver B, who is going to turn left and travel on in northern direction i.e. in the opposite direction of driver A .

There were two possible interpretations of the situation. Driver A chose the wrong one. This is a typical rule-based mistake. This type of errors ought to be a challenge for the designers of the system. Man is used to verbal communication, which isn’t possible to make use of in traffic. Instead we have to relay on our interpretation of the behavior of our fellow road users. It’s therefore important to design the technical part of the system in such a way that it minimizes the risk of misinterpretation. In the presented example accident the solution is simple. Separate the parking area from the road by a fence in such a way that it forces the vehicles to enter the road in right angel.

Finally Reason talks about knowledge based mistakes. I.e. errors made because the road user doesn’t know what options he has. The road user education ought to be of such a quality that these types of errors would be very rare in the tactical ad operative part of the road users’ task. This type of mistake is probably most common in the strategic part of the road users’ task. In the accident with the right turning lorry above we found a serious knowledge based mistake. As you remember the driver of the lorry was very familiar with the situation as he had been traveling through that crossing several times every weekday for a couple of years. With a more conscious planning of the transport a much safer road for such an extreme type of lorry could have been chosen as there were several optional roads available.

Human errors have here been described from the road users’ point of view as a failure to accomplish the intentions of his action. Road users breaking the traffic regulations could also be described as human errors but of a completely different type. It’s definitely errors in the eyes of society as it often increases the probability of accidents to happen and the injuries resulting from the accidents. In the strategy of 0-vision these two types of errors, i.e. errors due to mans imperfection and errors in the sense of road users breaking the law, results in the division of responsibility between the designers of the road traffic system and the road users. It's the designers' duty to make sure that no one is killed or severely wounded as long as the road users don't break the traffic regulations. I find it important to point out that this means that it's important to design the system not only to minimize the consequences of accidents but also to minimize the probability of human errors and there by the probability of accidents to occur.

Traffic safety work has to a large extent been concentrated on the tactical and operative part of road users' task. I think that there is an important safety potential also in the strategic part of the task that often is forgotten. But most important of all is that a successful traffic safety work demands a very broad repertoire of measures. The road users must be given good education and training and the technical parts of the system must be adapted to the characteristics of man in order to minimize the probability of human errors as well as the risk of serious injuries when accidents after all happened.

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EDUCATION, ENFORCEMENT, AND CONTROL – MANAGING BEHAVIOUR ON THE ROAD

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In earlier papers, you have heard about the way in which the role of human error contributes to reduced safety and how a system approach, bringing together road design and vehicle design, is now becoming recognised as the best way of maintaining a downward trend in road casualties. I am going to discuss how we might also manage road user behaviour more directly, both within and alongside this system approach.

Unsafe behaviour has traditionally been seen as one of the three contributors to accidents, alongside faults in the vehicle or the road environment. In this context, unsafe behaviour has been defined as behaviour leading to accidents. The model we now have is one which asks more clearly – does the behaviour fit within the bounds of the system we are proposing, or does it fall outside. If it falls outside it does so for two broad reasons, either skill or knowledge is not sufficiently good to meet the demands of the system, or the rules of the system are purposely not obeyed. I am going to discuss some issues that arise in developing policies to minimise the occurrence of both these situations. But equally important is to consider where the boundary is between behaviour appropriate to the targeted "safe system", and behaviour that falls outside it. This must also be an important consideration for policy makers.

The safety system principles that you have heard for better road design take as a starting point that vehicle occupants should be restrained, that they should not be impaired by alcohol, and that they should be keeping within the design speed principles on which the system is based. The same is true for setting standards for the passive safety of vehicles.

It might be simple to assume that lack of skill or knowledge should be treated through better education, that purposely inappropriate behaviour should be treated through enforcement, and that a set of system rules, once defined, should be the basis of normal behaviour. But the reality is more complex. Public attitudes have a strong influence on behaviour. It is therefore also important to understand what is influencing attitudes and expectations in terms of the safety of the road system. Where attitudes are out of step with the proposed system rules, then both education and enforcement policies may be needed, and system rules may need to be redefined.

So let us first consider each of the three areas of behaviour that are most commonly targeted by policy – seat belt wearing, drink driving, and speeding. The policies adopted in different countries are similar – a mixture of education and enforcement. Their overall success is strongly influenced by national cultures, but there is much in common in the way in which the policies operate. I am going to use particularly examples from Sweden, the UK, and the Netherlands – which were the subject of the SUNflower project (Koornstra et al, 2003). I shall also focus on general characteristics of policies, rather than specific details.

One important aspect of policies targeting behaviour is timing in relation to the state of public attitudes on the issue. Sweden and Netherlands introduced front seat belt wearing regulations much earlier than Britain, resulting in a gradual rise to high wearing rates, with Netherlands still below 90%. In Britain, the delayed introduction meant that public opinion was already much more in favour, and most cars were already fitted with belts, with the result that wearing rates rose very rapidly to a high level which has since been maintained. In comparison, rear seat belt wearing in Britain has been introduced gradually without any single high profile change with the result that wearing rates have risen only gradually.

A slightly different issue of timing is illustrated by the publicity against drinking and driving in Britain during the 1980s. Here, the important issue is to develop the message in line with the change in public attitudes. The publicity message was aimed at gaining public acceptance step by step of the following statements:

- "Drinking and driving is risky" (at this stage it was still assumed that it was other driver's behaviour that was at fault)
- "My drinking and driving is risky"
- "I am prepared to put up with a change in my drinking and driving habits"
- "I do not want to change my drinking and driving habits, but I am putting close friends and family at risk"
- "If I do not change my drinking and driving habits, I will lose my licence and maybe my job"

In parallel to this developing message, the level of enforcement was increased.

The starting point of any policy targeting behaviour is to understand, and if necessary improve public awareness of risk. This can be represented to the public in various ways. Typical illustrations from British advertising are

For rear seat belt wearing – "the elephant in the back of your car"
For fatigue – "dying in your sleep on the motorway"
For speeding – "the extra 5m travelled on an urban road results in the child being hit"

But behind these illustrations, there must be good scientific evidence.

Risk curves relating to alcohol impairment were established in the USA many years ago – a similar study has recently been repeated. Similar risk curves have been developing in several countries (eg Maycock, 1997). There are different views between countries as to how these should be used in setting national legislation. This is partly because the final outcome in terms of levels of drinking and driving that remain, and the resulting increase in road casualties, depends not only on the limit set, but also on enforcement levels and on the penalties applied by the courts. These latter in turn are influenced by more general public attitudes to the laws on drinking and driving. The Sunflower comparison showed that the legal blood alcohol limit is lower in Sweden and Netherlands than in Britain, and the enforcement rates are also higher, but the penalties if convicted in Britain are higher than in the other two countries.

Recent research in several countries (Taylor et al, 2000; Kloeden, 2002) has shown that similar risk curves can be developed for speeding. These relate to the risk associated with drivers who generally adopt higher speeds than the majority of other drivers on all roads. Further it can be seen that the added risk for those who drive at speeds around 20% higher than the average speed is of the same order as the risk level at which alcohol limits are set.

We also know from separate studies that the added risk for drivers choosing speeds above the average varies with road type and quality. Generally the proportionate effect is greater where roads are of poorer quality. So the effects need to be related to the different road networks in different countries. In Britain, for example, the greatest gains from dealing with speeding, in terms of reduction in total casualties, are to be found from enforcing speeding on urban roads, although significant benefits can be gained in reducing fatal and serious casualties, by targeting rural roads.

These data are important for both public awareness policies and enforcement policies. There is still a long way to go in most countries in changing attitudes to speeding, but progress can be seen (eg Stradling et al, 2003). In recent years in Britain, there has been a substantial increase in the use of speed cameras for enforcement. This has resulted in much public concern, particularly because the schemes are financed by the revenue they generate, and it is easy therefore for the public to mistake the motives of the scheme managers. Studies have shown clear benefits from the schemes, but their continuing acceptance requires constant positive publicity.

The broader acceptance of speed polices also needs the consequences for safety to be set alongside those for mobility and for the environment. While safety engineers can make a strong case for a speed reduction, the effects on other transport policies and on the transport economy must be recognised and a balance sought between potentially conflicting interests. Assessment procedures are currently being developed in Britain for revising speed limits on rural roads, using this approach.

An important aspect of enforcement policies is to achieve long term compliance. This is often attempted by offering re-education alongside punishment, or in some cases as an alternative to punishment. This is quite common in drink drive policies, and in some countries for more general driving violations. Again, clear benefits can be seen from this type of policy, but the extent of the policy will depend in part on the whether the target population is a small group of persistent offenders or whether the course are aimed more generally at influencing at views of a large proportion of road users. Removal of the licence of persistent offenders may be seen as an alternative solution, and may be necessary in cases where re-education fails, but it brings with it a further potential problem, of an increase in the number of drivers who use the roads without a licence. So the interaction of these policies needs to be treated with care.

If there are limits to what can be achieved with education and enforcement, what could be the added role of more direct control of vehicle users? In all three areas already discussed – seat belt wearing, driving while impaired, and speeding – technological solutions exist that could be applied to control behaviour more directly. Vehicle manufacturers have brought forward other systems aimed at, for example, lane keeping, collision avoidance, and enhanced vision. For some of these systems, more work is still needed on their technical capability and their potential use within the normal driving task. Their wider introduction also depends on their integration within an automated vehicle highway system, and the availability of, for example, satellite location systems built to a common architecture covering many countries. Progress is being made – the European Commission for example has just issued a document on Information and Communications Policy for Safe and Intelligent Vehicles (European Commission, 2003). At the same time there are experiments in progress nationally with these systems, but their effect on national casualty totals is unlikely to be seen for some years yet.

The biggest potential is likely to be from speed control systems. Experiments with voluntary speed control have been conducted in Sweden, Netherlands and Britain. These have shown the practicality and acceptability of the systems among the sample of drivers that have used them. But there remain considerable concerns among the public in general about both the practicality and the ethics of a system of mandatory control. It is likely to take up to 10 years further work to change these views.

There have also been experiments, notably in Sweden, in the use of Alcohol interlocks. The majority of these have been with professional drivers. But In Sweden interlocks have also been used to help drink dependent drivers to change their drinking and driving behaviour, with promising initial results.

Two of the biggest concerns that remain about any of the systems that directly intervene in the driving task are

- the extent to which they encourage variations in driver attention to the driving task which will result in less safe behaviour in those tasks where action is still needed by the driver . For example, low speeds are needed in residential areas because of the likely conflicts with vulnerable road users. But low speeds on their own are not enough, the driver needs to be ready to react quickly if a conflict arises.
- the extent to which information from an automatic source appears to be in conflict with the information being processed directly by the driver

The need to manage the effects of new technology is well illustrated by the issues surrounding the use of mobile phones. Some countries are now legislating or issuing advice to drivers not to use hand held phones. Use of a hand held device clearly has potential to interfere with the driver's control of the vehicle. The influence of hands free phones is less clear. Some claim that the possible reduced attention to the driving task is no difference from other potential in vehicle interactions such as talking or listening to radio. Several simulator studies have explored this issue. A recent TRL study (Burns et al, 2003) suggests that impairment of driving ability during a phone conversation can be greater for certain aspects of driving performance than impairment from alcohol, even allowing for the fact that drivers tend to lower their speeds when using the phone.

So far I have been focussing on reducing casualties resulting from behaviour that falls outside that on which the majority of the road and vehicle system is proposed to function. Let us turn now to the issue of trying to ensure that the behaviour on which that system is based is consistent with the behaviour of the large majority of the population. This is dependent not only on the public perception of risk but also the extent to which other objectives are in conflict with that perception.

For seat belt wearing and drinking and driving, the attitude for the majority is in line with behaviour consistent with a safe driving system. But for drinking and driving this has only been achieved by managing drinking behaviour, and for some countries this is still in conflict with traditional lifestyles. Adolescents will often have quite strong views about the dangers of drink driving, but as drinking becomes more prominent within their lifestyles, each generation needs to be helped to manage that behaviour. There is therefore a continuing need for drink drive publicity. For speeding, we have yet to see the same change towards personal management of behaviour even among mature drivers. Publicity campaigns are needed that move beliefs and behaviour in a series of steps towards that consistent with a safe driving system, if the full benefits of that system are to be realised.

Whilst a greater degree of control may be one way of achieving this change, it also brings other problems. Once some external control is applied, road users expectation of safety increases. This affects not only the level of safety they expect, but also the extent to which they see their own actions as being responsible for maintaining that level of safety. So it is imperative that any control system is sufficiently well integrated into the overall driving task to ensure its benefits are not eroded by an inappropriate reduction in the driver's contribution to avoiding risk.

The introduction of external control also has important implications for the managers of the system. In Britain, there is clear evidence of higher expectations of safety from publicly managed transport systems such as rail, than from systems which are based on individual behaviour. These expectations are expressed through the media and through politicians, and can result in pressure for policies which are then based on distorted valuation of casualties saved by one system compared with another.

In both urban and rural safety situations now there is a need for a close dialogue with representative road user bodies to ensure that safety measures that are introduced are fully understood and accepted. In Europe the DUMAS project (Wells, 1999) explored the processes for doing this for urban safety management. The European Road Assessment Programme (Lynam et al, 2003) is developing concepts that could be applicable to improvement of the interurban road network. A similar approach is likely to be important as the balance of control within the system is changed.

Finally, it is important to understand what others factors are influencing road user behaviour and how these might affect progress towards casualty targets. Monitoring progress in Britain has shown up that fatal accidents are not declining as quickly as serious injury accidents. This could be due to changes in reporting levels but this does not seem to be the case. Rather there are indications that the standard of driving behaviour may be declining. To monitor this properly, regular surveys of driver behaviour are needed which are not yet in place in Britain (or in many other countries). One aspect of this could result from the growing use of vehicles as mobile offices (Broughton et al, 2003). Another minor, but interesting factor is the evidence of a growing disparity in the size of vehicles, leading to more collisions between small and large vehicles, with resulting greater injury severity. Such changes are driven by other market forces; but safety strategies should try to take account of them.

In summary, there are a wide range of potential policies that can be applied and it is important to apply them so that they work most effectively together, taking account of the safety problem and the attitudes and culture of each country. How do the various policies relate to casualty reduction targets. The SUNflower project compared the policy areas expected to contribute to the national target over the next few years in Sweden, Britain, and the Netherlands. There is still a substantial saving to be gained in many countries by reducing alcohol impairment – in Britain up to 15% of fatalities but only a small proportion of this is being targeted. Achieving 100% seat belt wearing has much less potential. The potential gains from reducing traffic speeds depends on the balance between speed and mobility considered appropriate for different roads in each country, but practical policies effectively implemented are likely to achieve at least 10% reduction in fatalities. Fatality rates among novice drivers are well above those of experienced drivers, and you have heard some encouraging results from Sweden.

Particular road user groups may also need special attention. In Sweden, the dominant casualty group are car occupants, and this enables a clear focus on a safe road system designed around this mode. In Britain, 20% of fatalities are still pedestrians so it is crucial to decide what rights and facilities they should be given within the safe road system. Another major group are fatalities among two wheeled riders. In Britain these are mainly motorcyclists, but in the Netherlands cyclists and scooter riders. The Netherlands has shown that improved road environments can produce low risk per cyclist trip. But for motorised two wheelers, it is very difficult to decide what freedom they should be given within the safe road system, and the extent to which the system should protect them.

The challenge for Japan is to decide what behaviour is appropriate to the safe road system you wish to establish, and to create a programme of policies combining the wide range of tools that I have discussed in the most appropriate way to focus on those aspects of behaviour most relevant to safety problems in Japan.

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