Road traffic in the Netherlands: Relatively safe but not safe enough

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Road traffic in the Netherlands: Relatively safe but not safe enough!

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Introduction

The Netherlands—a small, densely populated country in North Western Europe, about as big as Rhode Island—has a population of about 16 million, nearly 135,000 kilometers of paved roads, and about 7 million cars. It has quite a large number of historical city centers that are centuries old. Recently, a music festival was held in one of them, Utrecht. The performances took place on a boat on a canal, and the audience was spread along the walls on either side. There was a wooden stairway connecting the street to a lower path along the moat. A lot of the audience was standing—watching and listening to the performance; there were so many of them that the stairway came loose from the wall and collapsed. Dozens fell into boats under the stairway and in the moat. Ten of them had to be taken to the hospital, and three of them were severely injured. Since then, one of the three had died in hospital from the injuries incurred.

The people on the stairway assumed that the designer and owner of the stairway had ensured that it was safe to stand on. After all, nobody had been warned beforehand that their safety wasn't guaranteed. After the accident, the question was immediately asked about who was responsible and, thus, to blame. A scapegoat was looked for. Should the visitors have been more careful? Could the organizer of the festival have better guaranteed a safe outcome? Should the owner of the stairway, the city council, have built a safer one or closed it before the performance? Should there be no more stairways or no more festivals? No, we find it very difficult having to accept such drastic solutions: "everything should be allowed" seems to be a sign of the times here. In society there is a fundamental awareness that risks, if there are any, are either controllable or should be.

After such an accident there is usually an "independent inquiry," but I predict that the conclusion will be that the risks were not well known, neither by members of the public, nor by the festival organizer, nor the owner of the stairway; and that rules and regulations had been broken. *The accident need not have happened.* This means, in general, that stricter rules will come, and it will be agreed that their compliance will be better controlled. There will then be notice boards everywhere with "warning" and "danger" on them. The option of "no more stairways or no more festivals" is regarded as socially unacceptable. "Crowds of people are always dangerous, but it nearly always ends well," so why prohibit or even limit them?

Modern Dutch society has a great amount of material certainty, and less welfare is regarded by the overwhelming majority as undesirable. Society feels partly responsible for this, and does not

leave the individual completely to his or her own fate. We are not able or willing to do without economic and welfare growth. However, society needed technological developments to get welfare as high as it is now and needs it to maintain this high level and to raise it even further. Examples are energy supply, data communication, and transport. However, many technological developments generate their own risks, and these risks are indeed regarded as small ones, but they cannot be totally eliminated. They have become smaller in time and can be made even smaller, but a society without risks is practically unimaginable. This raises the question: what is safe enough and how much are we prepared to pay for lower risks?

In this essay, I will delve deeper into this question from the perspective of the safety of road traffic. Can such a lot of road traffic be even safer, and how can it be achieved? It is also interesting to investigate who is responsible for crashes and who bears what responsibility for preventing crashes and casualties. I will answer these questions from a Dutch perspective.

Reduction of traffic risks

It is estimated that every year 1.2 million people are killed in road crashes throughout the world (Peden et al. 2004). The Netherlands belongs to the safest countries in Europe and in the world. Road traffic is relatively safe in the Netherlands.

Over the decades, many highly-motorized countries, such as the United States and Western European countries, have seen decreases in the number of road casualties. These reductions are impressive, even more if we take into account the increase in motorization and the kilometers traveled in all of these countries (Table 1).

Table 1. Overview of the reductions in the number of road deaths in the 1970–2004 period for several highly-motorized countries. Source: International Road Traffic Accident Database (IRTAD).

Country	Change 1970–2004
Australia	−58%
Japan	−61%
Canada	−46%
United States	−19%
France	−66%
Germany	−73%
Great Britain	−57%
Netherlands	−75%
Spain	−13%
Sweden	−63%
Switzerland	−69%

The greatest reductions in fatalities are observed in this period in Western European countries (almost 60% reduction). After leveling out around the year 2000, a new decreasing trend can be observed the last couple of years. In the United States, there has been a slower decrease than in Europe, and no real progress can be observed the last couple of years (NHTSA 2004). Although the USA has achieved a decrease in fatality rate per distance traveled (a yardstick used in the USA), the reduction of fatalities is far less than in many other highly motorized countries. This probably also applies to the number of injured and amount of material damage. During the last few years, the annual number of road deaths has been about 40,000. It is striking that the USA, in contrast with many other countries, has chosen a ratio to measure road safety development, and not the absolute numbers of deaths and injured. After all, ratios can decline while, simultaneously, the absolute numbers increase—a politically undesirable situation that is also not very easy to explain to the population. In the political debate about this subject in the Netherlands, we have, therefore, opted for absolute numbers. Since the 1980s, we work with quantitative road safety targets which are formally determined by Parliament. The positive numbers in 2004 and 2005, 19% and 7%, respectively, fewer fatalities than the previous year, led the Minister of Transport to announce that she wanted the targets for 2010 and 2020 to be lowered.

The results of Table 1, of course, offer neither a single insight into the reasons why countries differ from each other nor any further insight into explanations for a development in a country nor clues pointing to the policy performance of a country. Analyses are needed to do this. In recent years various attempts have been made (see, for example, Koornstra et al. 2002; Wegman et al. 2005; Johnston 2006).

The developments in the Netherlands are impressive—a reduction of 75% in about 35 years—from more than 3,200 road deaths in 1972 to about 800 in 2005. Until now, we have not been able to completely explain this reduction, only partly. For example, we know that many effective measures have been taken during the past decades (Koornstra et al. 2002). We can illustrate this further by examining the risk development in traffic; very many of the road safety measures try to lower this risk. As in all highly-motorized countries, the risk in the Netherlands, expressed in deaths per motor vehicle kilometer, has declined (Figure 1).

This trend shows a general exponential decay, a mean reduction rate per year of about 6.5%, although major deviations from this mean value can be observed. As said, a large number of measures has contributed to this decrease in risk, including the introduction of road safety legislation such as general speed limits and an alcohol limit in the seventies, the extension of the (relatively safe) freeway network and more and better facilities for pedestrians and cyclists (such as traffic calming) and bicycle paths in the seventies and eighties, more and more efficient police enforcement in the 1980s and 1990s. However, there is no all-embracing explanation.

But the idea that more traffic must lead to more casualties is demonstrably incorrect. The idea that the increase in traffic and the decrease in risk is a constant is also incorrect. There is, therefore, no such thing as a predisposition to a number of casualties or to a risk. That is an important observation and is optimistic, even if we are not able to completely explain past successes. Although there is still an increase in exposure to danger, the number of road deaths has declined considerably.
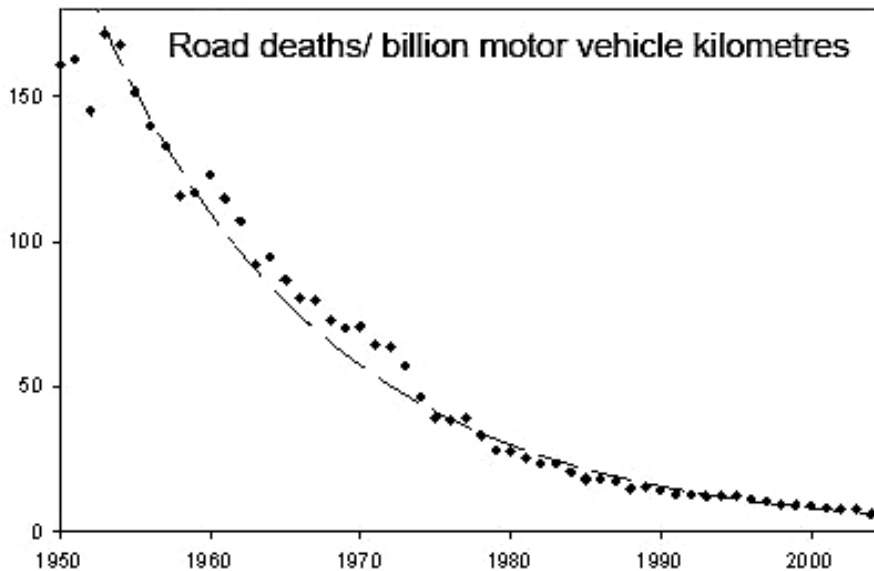
Figure 1. Road deaths per billion motor vehicle kilometers in the Netherlands, 1950–2004. Source: the knowledge base at www.swov.nl.

In spite of these improvements, we have to make a second important observation—that traffic participation inevitably brings risk. The risks in road traffic are many times greater than in other modes of transport. Further analysis of these risks teaches us that *road traffic is inherently dangerous* (Wegman and Aarts 2006). This means that the road traffic system was not designed with safety in mind, as were railways and aviation. This means in turn that road crashes today are to some extent inevitable and the question is then, how to eliminate dangerous situations in road traffic and thus reduce the chance of crashes, severe injury, and death.

Road traffic without risks?

In modern society, there are many different risks, and hardly any are regarded as acceptable. Risks in road traffic can be objectively compared with other risks, such as natural disasters. When regarded as a national health problem, road-crash injury can be compared with other health threats. Such comparisons invariably teach us that road traffic involves relatively great risks. Somebody once reasoned that the present status quo would be a good indication of the acceptance of risks in society; otherwise, society would do something about it. This reasoning does not make sense if we see which political statements are made in many countries. For example, the European Union has the ambition to halve the number of road deaths in ten years—2000–2010 (European Commission 2001). The problem is much more a matter of how to lower risks and at what price.

However, as already mentioned, a modern society without risks is difficult to imagine. That is why the moral goal of "zero fatalities" as in Vision Zero in Sweden is a good and, perhaps, the only correct starting point. However, the pressing question remains: what is sufficiently safe? My opinion is that a society will never accept the current level as long as there are possibilities, even utopian, of lowering the risks and decreasing the number of casualties. In previous publications we have called it the principle of *avoidable crashes* (Wegman 2000). This principle

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goes as follows: if crash causes are known and we know that they can be eliminated via cost-beneficial investments, then there are indeed avoidable crashes. So long as such crashes occur, there is social pressure to avoid them, or this pressure to prevent avoidable crashes can be created. One of the most important roles for social organizations, such as consumer organizations and automobile clubs, is to make clear that avoidable crashes occur and to win social support to prevent such crashes. If many citizens are not aware of the risks or of the fact that risks lead inevitably to avoidable crashes, then it's their job to make them aware of it. Research has shown that, when asked, (Norwegian) citizens have a good sense of risks and risk differences (Elvik and Bjørnskau 2005).

If you look at the large risk differences between the transport modes, the question is raised as to why society just passes these differences by with a shrug. For example, aviation is (by a factor of almost 30) safer per distance traveled than road traffic (ETSC 2003), and that a kilometer on a motorbike in the Netherlands is 15 times more dangerous than in a car. Evidently, the ratio does not rule here, and objectively talking about the risks is not the whole story. Not all risks are the same, and this also applies to casualties and crashes.

There is a great deal of knowledge about why people want to take certain risks or actually wish to avoid them. Examples are: voluntary vs. involuntary risks, risks you can control yourself or leave to a professional, one disaster with many casualties vs. many crashes with one victim per incident, the price you have to pay for not having to take risks, etc. There is more at hand than only the objective risk; there is also a moral and often also an emotional value of a risk. Seen from this perspective, and much less than from a purely rational cost/benefit-based approach, freeways have medians with barriers; nobody may just shoot through the barrier and crash into an "innocent road user." Innocent and vulnerable road users in the traffic mix—children and the elderly, pedestrians, and cyclists—can count on a great deal of sympathy in the Netherlands. Sometimes people speak of this very ideologically, but this certainly does not mean that the other group, i.e., motorized traffic, ranks second. There are two important factors behind this observation: the contribution of motorized traffic to the economy (not only to the economic product of a country, but its contribution to economic growth) and the "acquired right" of practically every citizen to be able to develop socially better via participation in motorized traffic. This concerns the improvement of road safety in general, and of special groups in particular. The result of this ultimately determines, to a great extent, the road safety improvement pace in a country. To weigh all these different interests, political decisions are needed.

Political decisions

Two questions are important for risk management: a) how to set the political priority for road safety compared with other social problems, i.e., to influence the political agenda setting and b) how to assess various, incomparable, and special interests, when reducing risks by certain interventions. Both questions require political decision-making.

In the Netherlands for the last 20 years, we worked with a quantitative road safety target. This target has two aims. First of all, setting road safety promotion as a political priority. Such a priority means that road safety is carefully weighed against other priorities. Second, it is necessary that stakeholders, if needed, perform more activities to achieve the target set. In a recent publication, it was made plausible that "the establishment of quantified road safety targets

have an appreciable association with an improvement of road safety" (Wong et al. 2006). It is beyond dispute that political decision making can be influenced by social organizations. In many countries, lobbying has been elevated to an art. Also, research institutes using impartial, scientific-based knowledge can be very influential.

By including the subject of road safety on the political agenda, for example, via a mobilizing quantitative target, it then perhaps becomes a contributory factor in an effective road safety policy but is certainly not a sufficient precondition. In Netherlands politics, road safety is not an issue that separates political parties. All Parliamentary parties treat it as an important issue. For many decades now, all Dutch Governments have been coalitions of two or more political parties, and they have all come to the conclusion that road traffic was not safe enough. What does divide political parties is the rate of improvement and the price to be paid for it. Reducing exposure to danger, e.g., by restricting or excluding certain groups from participation in traffic, is not a popular way of achieving this. To illustrate, Parliament recently rejected a Government proposal to raise the minimum operator age for mopeds from 16 to 17 years.

The limitation of existing individual freedoms or considerable burden increases for citizens/consumers is generally an extremely sensitive matter. The reasoning for this often shows not a great deal of courage; let's first try to achieve our goals with less far-reaching measures. If, in the event that it does not work, then further-reaching measures will be considered; also known here as "the big stick strategy." This reservedness does not apply when punishing individual road users if they, for example, have been found guilty of causing a crash by driving too fast with a much higher Blood Alcohol Content (BAC) than the legal limit of 0.05%, etc. More severe punishments for people causing crashes are discussed regularly in the Dutch Parliament. A main issue in Parliamentary discussions, and discussions in provincial and town councils, is the expected public response to new initiatives.

Public attitudes, opinions, and preferences

As far as Dutch citizens are concerned, road safety is the highest priority within the theme "traffic and transport," and it is considered to be of both societal and personal importance. However, although people see road safety as something that should be given a higher priority by government, this opinion appears to be held somewhat less strongly, as Table 2 illustrates.

Table 2. Percentage of respondents who agree or strongly agree with statement mentioned about the various subjects (2005).

Subject	Of (big) societal importance	Of (big) personal importance	Should get government priority
Road safety	96%	95%	79%
Ignoring traffic rules	92%	87%	80%
Infrastructure maintenance	92%	68%	69%
Punctuality of trains	88%	29%	79%
Travel time	78%	47%	64%

The relatively greater risk in road traffic, when compared with other public health threats, does not make much impression on policy makers and opinion leaders. What does impress them are the relatively great risks of vulnerable and innocent road users: children, the elderly, pedestrians, and cyclists. Social organizations such as the Royal Dutch Touring Club ANWB, the Dutch Cyclists' Union, and the Dutch Traffic Safety Association pay a great deal of attention to these groups of road users and, without any doubts, they influence political decision-making on this. Furthermore, what also seems to impress are major road crashes. These crashes get a lot of media coverage, and this media attention not seldom results in preventative action.

Periodically in Europe, a study is carried out in which questions are asked about opinions and attitudes of motorists concerning road safety issues. In the meantime, this study has been carried out three times—in 1991, 1996, and 2002. The results show that, in general, the Dutch motorists support many of the measures taken to improve road safety (Goldenbeld 2003). This means that improving road safety does not involve a struggle with the entire population—at the most, just some of them. Support has been expressed for further-reaching measures: introduction of a demerit points system, no alcohol *at all* for novice motorists, more police surveillance, etc. There is also a considerably increased interest for new devices in the car such as a navigation system and an alcolock (to prevent drunk driving). A black box that records information about the cause of a crash seems to be getting accepted. There are, of course, other subjects about which the Dutch motorists are doubtful, and the most important of these is the speed limit on freeways. This sort of information is important when preparing policies and when trying to get political support for certain interventions. There are indications that the greater the support for certain measures is, the more probable the spontaneous compliance will be and the less the enforcement burden will be.

However, even with a rather large amount of support, there is no certainty that every measure can hope for the people's support. In addition, there is nearly always a certain amount of natural skepticism about what the government decides. This means that the quality of policy implementation requires a lot of care and attention. Social organizations are in such matters the voice of mature and well-educated citizens. Policy performance depends on many factors.

Effectiveness of policy performance

A number of general lessons can be learned, based on the general knowledge about the effectiveness of policy performances and, in particular, the contribution towards this policy implementation. In essence, this involves three terms (Glasbergen 1987): *knowing, being able, and wanting*. An implementer must know what is expected from him, one must be able to implement the policy, and want to do so. The "knowing" is a question of communication between commissioner and implementer. Being able is a matter of: money, time, personnel, and knowledge. Wanting is a matter of (vested) interests, pros and cons for an organization involved in implementation, etc.

These general lessons have been summarized in two check lists (Figures 2 and 3).

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┌─────────────────────────────────────────────────────────────┐
│                                                             │
│   1. Create political support                               │
│                                                             │
│   2. Define goals/objectives/targets precisely              │
│                                                             │
│   3. Use valid causal theory (problem – solution)           │
│                                                             │
│   4. Organize enough means (implementation + monitoring)    │
│                                                             │
│   5. Reduce necessity of inter-organizational decisions     │
│                                                             │
│   6. Use sanctions/incentives for                           │
│                                                             │
│        -  co-producers                                      │
│                                                             │
│        -  target audience                                   │
│                                                             │
│   7. All stakeholders should prioritize implementation      │
│                                                             │
│   8. Encourage active support of stakeholders               │
│                                                             │
│   Or: organize effective 'delivery mechanisms'              │
│                                                             │
│   ─────────────────────────────────────────────────────    │
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Figure 2. Checklist of the quality of a policy document to improve policy implementation. Source: Mazmanian and Sabatier (1981).

The first checklist is related to the contents of policy documents; the second is a checklist related to the implementation itself. These checklists were made more than 25 years ago (Mazmanian and Sabatier 1981) but are still just as relevant. What is surprising is that, apart from a checklist about the implementation itself (Figure 3), there is also a checklist of policy document require- ments (Figure 2): a good policy document can increase (the value of) good implementation. Moreover, Mazmanian and Sabatier are of the opinion that, in a democratic system, those elected must support a policy document, then the civil servant organizations and others.

Note that in Figure 2, as many as three of the eight points refer to the support of stakeholders who should be included in the policy document (items 5, 7, and 8). So, these can be considered as core recommendations for a good policy implementation. A policy must, ultimately, be sufficiently clear that the term "effective delivery mechanism" is applicable and the responsibilities for these delivery mechanisms must also be seen to state that—preferably in the policy document itself and not just when it is being implemented (only to discover by then that there is no effective policy implementation at all).

If a policy document has been determined (either a Strategic Plan or an Action Plan), implemen- tation can begin. If we assume that then, as much as possible meets the requirements of Figure 2, it is recommended, from Day 1 on, to keep an eye on things. To do this, the checklist of Figure 3 can be used.

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1.  Monitor economical/social/political environment
2.  Monitor public support
3.  Monitor progress of policy implementation
4.  Monitor support of key-stakeholders
5.  Monitor quality of 'delivery mechanisms'
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Figure 3.Checklist of the quality of policy implementation. Source: Mazmanian and Sabatier (1981).

What Figure 3 comes down to is the scanning of a policy context. After all, essential changes can occur in the implementation from the very first day onwards. First of all, policy context means the monitoring of the economic, social, and political environments. Just as important is the public support for the problems being tackled or the solutions proposed in a road safety program.

A third area of attention is the progress in the policy implementation. The more concrete that the policy plans indicate which countermeasures and activities should be carried out in which period, the easier it is to show the progress. It is also possible to test empirically the assumptions at the base of the policy program. It is possible that during the practical implementation there will be new, unforeseen problems.

A fourth area of attention is the support from the key-stakeholders for the implementation. Organizations are also confronted with new realities and adapt to them. Then it can happen that the support already offered disappears, without this being explicitly decided in practice. It is good if those responsible continually inform themselves of the extent to which stakeholders abide by their promised support for implementation.

Finally, there should be an effective "delivery mechanism" in a road safety action plan. Stakeholders have been allured/provoked or even forced to make their contribution, and assumptions are made as to how to deliver effective and efficient policy performances. Sometimes co-financing is used as mechanism, sometimes training programs, and sometimes covenants are signed, etc. Here it is also relevant to enquire if and how these "delivery mechanisms" work in practice.

This more theoretical approach about such an important subject as policy implementation was further studied in the SUNflower project (Koornstra et al. 2002). This project compared the policy performances of three countries: Sweden, the United Kingdom, and the Netherlands (the SUN-countries). A number of important conclusions about policy implementation are now presented.

The common and different policy and organizational features in the SUNflower countries

The level of traffic safety of a country is determined to a substantial degree by factors which lie outside the direct influence of its traffic safety policy or by the way those factors can administratively be handled by means of policies. Moreover, these factors might differ substantially for different countries. Both aspects are highly relevant in addressing the "common and different policy and organization features" of the SUN-countries. Such factors concern, for instance, the geography and characteristics of the landscape, the climate and the light conditions, demography and population characteristics, and, of course, the many aspects regarding the mobility and the traffic infrastructure of the three countries. With this previous remark and its implications for comparisons in mind, this section will merely be focused on comparisons of safety policy and safety organization. A more practical remark also to be made in advance is that safety policy and its organization can be addressed from different points of view or on different levels. Here, the hierarchical division of policy and organization into a strategic, a tactical, and an operational level is chosen.

On the *strategic level*, traffic-safety policies in the three countries have much in common. In each safety program, statements can be found that lack of road safety is not an unavoidable side-effect of road transport, but that it is the transport system which has to be fundamentally arranged in such a way that people can travel without the harm of fatalities and serious injuries. The implementation of this abstract objective requires its translation into tangible objectives and, in particular, into intermediate targets. Nowadays and for several years, each of the three countries has set quantified targets, monitored these on a regular basis, and—what is more—sharpened the targets over time to reach the eventual objective. The three most recent targets have different apparent fatality-reduction percentages over different periods to 2010, although in fact the British target does not have a separate fatality target. If compared to the actual fatality levels in 2000, and assuming the British target for fatal and serious injuries combined referred directly to fatalities, the targets for 2010 imply different fatality-reduction percentages need to be achieved between 2000 and 2010: for Sweden 32.5%, for Britain 37%, and for the Netherlands 29.5%. The British target appears to be the most difficult to achieve because the trend in fatal injuries shows that substantially less than the target percentage occurred for serious injuries in Britain over recent years. Against the actual target definition, the likelihood of reaching the 2010 target looks much better.

Target setting proved to be a valuable means to get, and to keep, traffic safety on the political agenda (Wong et al. 2006). It is also an efficient managerial tool to define responsibilities for the different levels of administration and among other stakeholders in the field. The actual policies in the three countries also correspond with each other to a great extent. This is expressed by the fact that each contains a set of similar points of specific attention. These points of attention mainly address the same types of problems, for instance: speeding, vulnerable road users, the infrastructure, drinking and driving, and so on—albeit sometimes in a more or less elaborated or intensified way.

Interestingly, however, the safety visions of the three countries differ. In principle, this could have different impacts on the way the safety problem will be handled. And, of course, different approaches might lead to different results. These differences in vision refer to the "Vision Zero"

approach in Sweden and the "Sustainable Safety" strategy in the Netherlands on the one hand, and the more problem-oriented and professional practitioner-led approach in Britain on the other hand. Although a shift in the application of certain types of solutions and measures can—at least in the Netherlands—be traced, it is still too early to demonstrate a corresponding difference in the safety profits in practice, when these are detectable at all. And the reason why is obvious.

The actual application of the Sustainable Safety principle in the Netherlands only started in 1998 on a limited budget. This is even more the case for the implementation of the Vision Zero approach in Sweden, operationally starting in 2000. Moreover, a part of the applied Sustainable Safety and Vision Zero measures belong to infrastructural measures that have already traditionally and intensively been used (e.g., roundabouts) in Britain. Stating a difference in safety vision is one matter, but answering the question why this difference has arisen between countries that have so much in common regarding their safety problems and policies is another. A clue might be the fact that achieving the safety target was no longer taken for granted in the Netherlands and Sweden at a certain point in time, while simultaneously it was concluded that some safety problems could not be addressed as before. This situation stimulated a search for a new approach. Possibly, an intensified application of existing measures still offers enough improvement opportunities, as the current British program is aiming to achieve.

On the *tactical level*, we have to deal with the practical means, sometimes expressed as the "toolbox of policymakers." It basically concerns the funding of a safety program, its organizational structure, the planning and decision making, and so on. It also concerns education, information transfer, enforcement, rules and regulations, guidelines, and so on. Enough expertise on such topics is certainly present in the SUN countries, while their organizational structures, although differing, are covering the same topics and expertise. On the tactical level, opportunities to influence mobility and the transport system from a perspective of traffic safety seem to be of more interest. After all, exposure and the conditions under which it occurs, are of major importance for traffic safety. Some clues can be found, but not enough to provide a clear focus in safety programs. Nevertheless, with regard to the Sustainable Safety strategy, indeed attempts are being made in the Netherlands to systematically transfer traffic onto the safer—higher—road types. However, attempts to encourage people to make use of safer transport modes, in particular public transport, are usually a result of lack of road capacity, leading to traffic congestion, etc. This kind of solution is, of course, especially relevant in metropolitan areas. Public support for safety measures is also essential. That public support is of great importance seems to be a lesson learned in each of the three countries. All safety programs refer to it, and in each, there is an attempt to create and foster public support. Different ways are being applied, presumably taking into account national preferences using studies that assess public attitudes.

The *operational level* is concerned with safety actions, (whether or not integrated with other fields of policy making like, for instance, the environment) and about specific measures. It is without a doubt that most well-known types of remedial action have been taken in all of the three countries. Broadly speaking, the only observable difference is, in fact, the timing. In trying to define differences, some account needs to be taken of the scale of application. In a way, the similarities should be expected. Among our "information societies," rapid exchange of knowledge and experience is usual, particularly in cases where we are dealing with the same kind of problems. With respect to this, the importance of road safety research also has to be stressed. Development of new approaches and publication of evaluations of their effectiveness in a

scientifically reliable manner has contributed and will significantly contribute to effective safety policies.

In all other countries, it is clear that national, regional, and local governments have played a leading role in improving road safety and that social organizations indeed influence government decisions. They sometimes even contribute to policy implementation, although this contribution is rather limited. This is also the case in the role the private sector plays. It would then be interesting to examine why the government has played such a central role in improving road safety and to ask ourselves whether the private sector could do more in the future.

Market forces and government

The market force is an important point of departure in modern micro- and welfare-economic theory. There are several reasons why a market can fail. Where investments in road safety are (or should be) made within a market setting, we can simultaneously distinguish numerous forms of market failure involving different stakeholders in a highly complex market. Market failures all have one thing in common: they reduce incentives for road safety investment below a level that would be socially efficient. This provides an economic argument for public intervention into the road safety market.

The diversity in market failure forms in road safety-related markets provides economic justification for the fact that the public sector has long been active in this area. The most important considerations are probably the following:

- The safety of road users can be regarded as a merit good, insofar as road users, for example, cannot assess the actual risk rationally and, thus, they underestimate it. Risk assessment is relevant in various behavioral choices prior to and during road use, such as purchasing a vehicle, purchasing safety devices and facilities, route choice, and executing various types of maneuvers.

- The interaction between road users concerns external costs in the sense that the safety risk inflicted by one road user on another is not reflected in market prices. People are liable for damage inflicted on someone else, but this liability does not cover (completely) all forms of damage, such as intangible damage. This deficiency is reflected in insurance premiums which are based on the payments that an insurance company has to make in crash cases rather than based on actual social costs. Furthermore, while insurance premiums are differentiated in the Netherlands (annual mileage above/below 20,000 kilometers, region, no-claims bonus systems, passenger car or motorcycle), etc., this does not come close to the extent to which damage risks differ between individual road users. This is also the case for the differentiation in premiums within the no-claim bonus system following damage caused and, as such, is a very bad predictor for the future damage risks of the insured person.

- External risk increases with every kilometer driven, which is not taken into account in the insurance premium. Even if all material and intangible damage to others were to be fully incorporated into insurance premiums, this would not result in a correct price per kilometer for the person who causes a crash. In addition, infrastructural safety devices and facilities (safer pavements, public lighting, road signs, roundabouts, etc.) are public goods, as is the

infrastructure to which they are often inextricably attached. They are public goods both in a purely economic sense (non-rivalry and non-exclusiveness) and in the more popular interpretation that governments—in their role as road authority—are usually responsible for these facilities. This has led to an active road safety policy being pursued by various public authorities.

A traffic system without public-sector responsibility might be conceivable for its human and vehicle components, but not for roads. Furthermore, road network construction and maintenance often form the key rationale for the existence of a public-sector authority.

This means that it has been good that the government has taken the lead to improve road safety in the past and that it is difficult to imagine how it could be any different in the future. The role of social organizations can partly be responsible for implementing the policy that the government has formulated. On the other hand, these groups can try to influence the government to ensure that a "more and better" road safety policy is being followed.

Then the question arises about which policy is effective and how this policy can be implemented as efficiently as possible. This question reverts to the question of why crashes actually happen and how they can best be prevented. During the past, this question has been answered in many different ways. Furthermore, in 2006 this question has been answered very differently by the road safety world. As long as professionals, organizations, and public opinion think differently, this lessens the effectiveness of policy performance. Policy formulating is influenced and shaped by many different perspectives. Different insights cause confusion, can demotivate, and lessen the possibility of cooperation and synergy. There is thus every reason to pause and look at the various insights.

Causes of road crashes and remedial measures

"Human action is a contributory factor in over 90% of road crashes. The principal emphasis of all road safety strategies must therefore be on improving road user behavior. This behavior needs to be informed and trained, and to be modified, so as to improve interaction between road users, to ensure consideration for others, and to reduce risk. In this way, a culture of road use is created that is both precautionary and proactive in relation to road safety." These sorts of sentences can be found in many policy reports on road safety, and international research supports the truth of these statements.

Human errors (in observations, decisions, and actions) play their part in just about every crash, and the point is to eliminate them and, if they still do occur, not to let them lead to severe consequences. This sentence gives the impression that human errors are much more important than errors in road design and that vehicle factors hardly play a part in causing crashes. A second conclusion for a superficial reader could be that crashes should mainly be combated by behavioral changes to be achieved by police surveillance, education, public information, and driving courses. Furthermore, it could be concluded that technical measures could prevent a marginal part of all crashes. These conclusions are not logical and, moreover, do not reflect the most recent road safety insights.

During the years of motorized traffic, there have been very many different ways of tracing crash causes and how they can best be avoided. Table 3 presents, by means of a few words, what the dominant thoughts in the OECD countries were (see also OECD 1997).

Table 3. Road safety "causes" as seen in time. Derived from OECD (1997).

Period	Characteristic
1900–1920	Crashes as chance phenomenon
1920–1950	Crashes caused by the crash-prone
1940–1960	Crashes are mono-causal
1950–1980	A combination of crash causes fitting within a "system approach"
1980–2000	The person is the weak link: more behavioral influence
2000–	Better implementation of existing policies "Sustainably Safe": adapt the system to the human being

Without dealing with them extensively, there are a number of interesting conclusions to be drawn from this historical overview. First of all, the "crash-prone theory" dates primarily from the phase in which the legal guilt question was the main one: which road user has broken which law and is, thus, both guilty and liable. This question was answered by the police on the registration form of a crash, finally decided inside or outside the court room, and used by insurance companies to determine how to compensate damages. In-depth studies have shown that there are few mono-/single-cause crashes; they are usually caused by and the result of a combination of circumstances.

Two other conclusions are relevant here. More "education" is not the best way of preventing human errors. A postal delivery company incurred a lot of damage to parcels because the employees threw them around. Throwing parcels was then forbidden and, because it still happened, they were told not to do it anymore. In spite of this, when the management decided to pack the parcels better, the company's damage decreased. In traffic, the question has been: should the human adapt to traffic or should traffic adapt to the human? Nowadays, the answer to this is *both*. This means that we cannot prevent human errors only by educating, informing, and sometimes punishing people. We must provide people with surroundings in which the chance of human errors is limited. This is the essence of the philosophy in Sweden (Vision Zero) and the Netherlands (Sustainable Safety).

Finally—do crash-prone road users really exist? Are a small number of road users responsible for a large number of crashes? The answer is: only to a very limited extent. Situations with an increased risk are well-known (alcohol, speed, poor visibility, inexperience, etc.). However, we know that having had a crash is not a good predictor of future crash involvement. Committing traffic offenses does correlate with crash frequency: the more offenses, the higher the crash frequency. The question should be asked about the extent in which the crash-prone approach can be more effective, not for the crash-prone themselves, but, by paying attention to this group, trying to promote good driving behavior in general.

It is important to understand that there are various ideas among road safety professionals about what the most important crash causes are and what the best way to prevent them is. A discussion about these paradigms can possibly uncover a difference of insight and then lead to a consensus.

Social organizations can pay an important contribution to these discussions among professionals and with the public.

This difference in insight is just as important if one is trying, for certain road safety measures, to win the support of social organizations and interest groups and, ultimately, citizens and the politicians. In the Netherlands, popular support is very important for winning political support. Various groups play an important part in this: politicians, social organizations, scientific institutes, policy civil servants, and the media. There are complicated interactions that do not follow fixed patterns, and their results are not predictable.

During the last few years, we have seen the appearance of two main lines (paradigms) in road safety. The *first* one is especially aimed at effective and efficient policy implementation. A lot of information has become available about several road safety interventions (see e.g., Elvik and Vaa 2004), and the idea here is not to develop new policy interventions but to improve the quality of implementing existing ones using evidence-based or research-based information. Greater effectiveness is a matter of scale and quality. Improving road safety in such a way that the number of casualties substantially decreases generally requires a considerable effort, given the relatively low frequency of crashes, their low densities in space, and the modest effects of most safety interventions. Large enough scale is a matter of sufficient means. There is also the quality of interventions and with it not only the effectiveness but also the efficiency of investments, i.e., the effect achieved per dollar invested. Knowledge and expertise are features of quality, and promoting road safety requires professional knowledge and should not be left to well-meaning amateurs.

The *second* one is the Sustainable Safety idea (see also Wegman and Aarts 2006). This paradigm assumes two observations: a) the current traffic system is inherently dangerous and b) intensifying current efforts could lead to fewer casualties but not to substantially safer traffic.

Sustainable Safety

The Sustainable Safety vision, as described in Koornstra et al. (1992), aims to prevent crashes and, if this is not possible, to reduce crash severity in such a way that (serious) injury is almost precluded. These objectives use a proactive approach of studying those traffic situations in which serious-injury-producing crashes can occur. The next stage involves two options: either the circumstances are changed in such a way that the crash risk is almost totally removed or, if a crash is inevitable, serious crash injury risk is eliminated. "Serious injury" is defined here as fatal injury, life threatening injury, injury-causing permanent bodily damage, or injury-requiring hospital admission.

In the analysis of and approach to preventing crashes or reducing the severity of consequences of dangerous situations, human capacities and limitations are the guiding factors: *"man is the measure of all things."* The central issue is that people, even if they are highly motivated to behave safely while using the road, make errors that may result in crashes. In addition, man is physically vulnerable, and this has consequences for injury severity when a crash occurs.

Taking into account these human characteristics as the starting point, sustainably safe road traffic can be attained by an integral approach to the components: "man," "vehicle," and "road." This

means that the infrastructure has to be designed such that it meets human capacities and limitations, that the vehicle supports the performance of traffic tasks and provides protection in the event of a crash, and that the road user is well informed and trained, and is controlled wherever necessary in the correct performance of the traffic task.

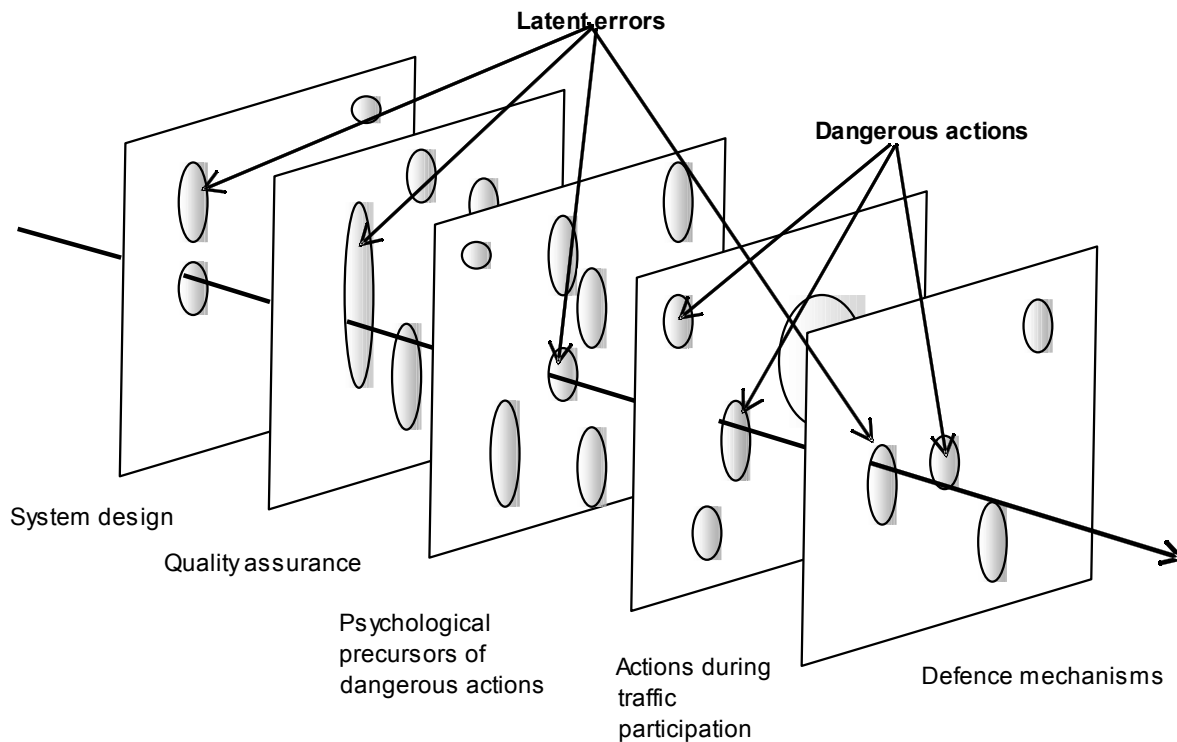## *Reducing latent errors in the traffic system*

Crashes are virtually never caused by one single dangerous action; in most cases a crash is preceded by a whole chain of events that are not well adapted to each other. For example, one or more dangerous road-user actions may cause a crash, or deficiencies in the traffic system may contribute to dangerous actions by road users leading to crashes. These system gaps are called "latent errors" (see Rasmussen 1983 and Reason 1990).

Latent errors occur in the following elements of the traffic system:

- The traffic system is defined as the organized whole of elements that create the conditions for traffic, such as:

  - Design of the system, where the potential for road crashes and injuries have been insufficiently taken into account.

  - Quality assurance in the establishment of components of the traffic system. Inadequate or lack of quality assurance of traffic system components can lead to errors that have implications for road safety.

  - Defense mechanisms limited to the traffic system itself. These do not comprise the defense mechanisms employed by road users while actively taking part in traffic, but, for instance, error-tolerant or forgiving infrastructure or Intelligent Transport Systems may help prevent a crash. These defense mechanisms are the last component in the chain leading up to a crash that can prevent latent errors and dangerous actions from actually causing a crash.

- Psychological precursors of (dangerous) actions. These are the circumstances in which humans actually operate or the states they are in that increase the risk for dangerous actions during active traffic participation.

Road traffic is characterized by a great many latent errors, particularly compared with other transport modes. Therefore, current road traffic has to be considered to be inherently dangerous. In the end, crashes occur if latent errors in the traffic system and dangerous actions coincide in (a sequence of) time and place during traffic participation (Figure 4).

Because dangerous actions can never be completely avoided, the Sustainable Safety vision strives to remove latent errors from traffic: the traffic system has to be forgiving to dangerous actions by road users, so that these cannot lead to crashes. The sustainable nature of measures is characterized by the fact that actions while taking part in traffic are less dependent on momentary and individual choices that can be less than optimal, and, consequently, increase risk.

Latent errors

Dangerous actions

System design

Quality assurance

Psychological
precursors of
dangerous actions

Actions during
traffic
participation

Defence mechanisms

Figure 4. Schematic representation of the development of a crash (big arrow) caused by latent errors and dangerous actions in different elements in road traffic (free after Reason 1990). If the arrow encounters "resistance" somewhere, a crash will not occur.

Adapting the environment to human capacities and limitations comes from cognitive ergonomics (also referred to as "cognitive engineering"), originating in the early 1980s from the aviation and process industries. In fact, this way of thinking has led to an advanced safety culture in all modes of transport, except road transport. Further incorporation of the Sustainable Safety vision should ultimately lead to a situation where road transport can also be considered as "inherently safe" because of such an approach

Another model that helps to understand the choices that are made within the Sustainable Safety vision—with man as the measure of all things—is the task capability model created by Ray Fuller (see 2005 for the most recent version). Fuller hypothesizes that a road user keeps the difficulty of the task, rather than the subjective risk, constant. In this theory, this subjective measure depends upon the ratio between the objective task demands and the driver's capability to accomplish this task. This task capability consists of a person's competencies, minus his situation-dependent state (Figure 5). People lose control over a situation if the task demands exceed the capability to execute the task. This is, of course, a breeding ground for crashes. Only an optimally designed, forgiving environment in combination with adequate responses of other road users can then prevent an injury crash. The task demands are, in the first place, influenced by road design, traffic volume, and the behavior of other road users, but the road user can influence the task demands in part, for example, by increasing speed, or engaging in secondary, distracting activities, such as using a mobile phone.
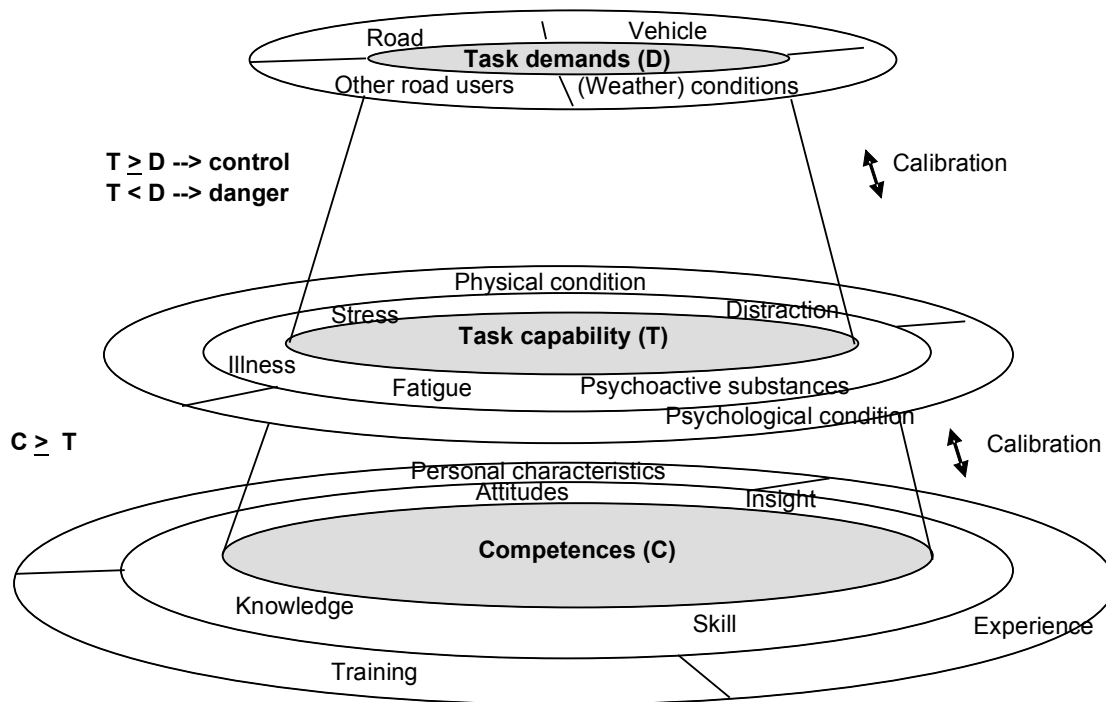
Figure 5. Schematic representation of Fuller's model: task demands (D) can only be met if task capability (T) is great enough. Task capability is the result of competencies (C), minus the situation-dependent state (in Wegman and Aarts 2006).

As is also known from the old arousal theory, people have a tendency to keep the difficulty of tasks (and consequently the corresponding activation level) at a reasonably constant and optimal level. In Fuller's model, this means an optimal ratio between task capability and task demands. If the task demands become too small relative to the task capability (e.g., being hale and hearty and well trained and driving at low speeds on a boring straight stretch of road with no other traffic), then people have a tendency to make the task more difficult to lift the feeling of boredom. Conversely, if the task demands are about to exceed the safe task capability (e.g., making a phone call while driving in busy traffic at high speeds), the driver will try to make the task easier.

The selected balance between task capabilities and task demands differs between individuals, as certain groups of drivers (e.g., young male drivers) tend to accept higher task demands relative to their capabilities, and consequently run a higher risk of crash involvement.

Taking into account physical vulnerability

In addition to human psychological characteristics, physical characteristics also play an important role in creating sustainably safe road traffic. The central issue is that human beings are physically vulnerable in impacts with comparatively big masses, hard materials, and large decelerations acting on the human body. The combination of these factors can cause serious injury, sometimes with irreversible effects, and even death. Some of the forces released in a crash are absorbed by the vehicle (if present). This means that people involved in a crash sustain

less (serious) injury as vehicles absorb more released energy. This also means that higher crash speeds and travel speeds are acceptable if the vehicles are more crash protective in their design, if vehicle occupants are wearing seat belts, if airbags are present, etc.

Given that people make errors, it is important in creating a sustainably safe road traffic system to design the environment such that these errors cannot lead to crashes or, if this is impossible, do not cause serious injury. The human body's vulnerability to injury, along with the important influence of speed on crash severity, is the starting point for a proposal for safe travel speed by Claes Tingvall, one of the founding fathers of the Zero Vision in Sweden (Tingvall and Haworth 1999; Table 1).

The starting point for this proposal is designing modern, well equipped cars and 100% use of seat belts and child restraint systems. However, safer speeds ought to be used in crash tests (such as in New Car Assessment Programs) but also in tests for protective design. In addition, as the car fleet does not yet consist of the best designed cars and seat-belt use is not yet 100%, the proposed speeds are too high for the current conditions. A higher degree of penetration of the best designed cars is necessary before the proposed speeds can be viewed as "the maximum allowable speeds." Taking the current fleet conditions and seat-belt use into account, it is, however, hard to say what are safe speeds at this time, other than that they are lower than the speeds listed in Table 4. These speeds are neither valid for motorcyclists, for example, who are much more vulnerable nor for crashes with relatively heavy vehicles, such as trucks.

Table 4. Proposal for safe speeds in particular conflict situations between traffic participants (Tingvall and Haworth 1999).

Road types combined with allowed road users	Safe speed (km/h)
Roads with possible conflicts between cars and unprotected road users	30
Intersections with possible conflicts at right angles between cars	50
Roads with possible frontal conflicts between cars	70
Roads with no possible frontal or lateral conflicts between road users	$\geq$100

To summarize Sustainable Safety

Given the fact that people make errors, they do not always comply with rules, and moreover, they are vulnerable, it is essential to prevent latent errors (or gaps) in the traffic system. According to the Sustainable Safety vision, in order to prevent serious unintentional errors, the environment and the task demands that this environment entails have to be adapted to a level that the majority of road users can cope with. This produces desirable behavior almost automatically —the road user knows what to expect, and possible errors can be absorbed by a forgiving environment. This also makes the breeding ground for intentional or unintentional violations less fertile. In so far as violation behavior prior to traffic participation can be detected (such as alcohol consumption or not having a driving license), denying traffic access fits within sustainable safe road traffic.

Road users have to be well informed and experienced to participate in traffic. Where their skills and capabilities do not meet the task demands, their safe behavior needs to be encouraged by means of specific measures. It is essential that road users are aware of their situation-dependent states and, consequently, their task capabilities, to take adequate decisions that may prevent potential crashes. Because there are differences in road-user capabilities, we should ask more experienced road users to engage consciously in safe traffic behavior directed at less experienced road users. A forgiving driving style can absorb the emergence of crashes caused by other road users as a social system.

The vulnerable human has to be protected in traffic by the environment by means of structures that absorb the kinetic energy released in a crash. To this end, the mass of vehicles sharing the same space needs to be compatible. If this is not possible, then speeds need to be lowered. This system is embedded in a traffic planning taxonomy of fast traffic flows on the one hand and access to residences on the other. Between these two extremes, traffic has to be guided in good, sustainably safe ways.

We finally arrive at the five central principles on sustainably safe road traffic: functionality, homogeneity, recognizability, forgivingness, and state awareness. A short description of these principles is given in Table 5.

Table 5. The five Sustainable Safety principles (Wegman and Aarts 2006).

Sustainable Safety principle	Description
Function of roads.	Mono-functionality of roads: as either flow roads, or distributor roads, or access roads, in a hierarchically structured road network.
Homogeneity of masses and/or speed and direction.	Equity in speed, direction, and masses at medium and high speeds.
Predictability of road course and road-user behavior by a recognizable road design.	Road environment and road-user behavior that support road-user expectations through consistency and continuity in road design.
Forgivingness of the environment and of road users.	Injury limitation through a forgiving road environment and anticipation of road-user behavior.
State awareness by road user.	Ability to assess one's task capability to handle the driving task.

Summary and recommendations

Traffic in the Netherlands is among the safest in the world, and this position has been reached by investing in road safety quality during a period of many decades. However, the Netherlands is not satisfied with the current traffic safety level. Striving for even greater safety is rooted in the understanding that many unnecessary road traffic casualties occur because road traffic is inherently unsafe. The current road traffic system was not designed with safety being an important criterion. Realizing this is essential for further improvements.

This does not mean that it is an easy matter to prevent all serious crashes. That is probably impossible. In the past, we have looked at different ways to find the best one for preventing road

crashes. This was attempted by using different paradigms that, first of all, had to be placed in the spirit of the times. On the other hand, scientific research has made our knowledge and insight much richer, and we now know quite well which interventions work and which do not. In the Netherlands a new paradigm was recently developed—Sustainable Safety.

Our insight into how social organizations and government can cooperate more efficiently to increase road safety has flourished. This is a complicated process in which politics, policy, civil servants, social organizations, scientific institutes, and the media each fulfills a role. There are no fixed patterns. Two subjects invariably play a role: how to get and keep road safety high up on the political agenda, and how to create support in society for road safety improvement measures. They can cling to the fact that in a highly developed society there is a strong undercurrent for risk management and quality stimulation. However, this process requires continuous attention and requires that stakeholders are and remain involved in policy implementation, with as its motto: *knowing, being able, and wanting*. Government should then organize itself in such a way that effective and efficient measures are taken that either, in advance, can rely on a large public support or in which social organizations make society ripe for acceptance. Political leadership, a leading agency, and road safety champions are key ingredients for successful policies.

I recommend the examination about how to give this process further shape, in the Netherlands and in the United States. It is difficult to imagine why the United States could not be one of the safest countries in the world if it wanted to be, and why the annual number of casualties could not decrease further. As a yardstick, I would not choose fatalities per unit of travel but the absolute number of casualties per inhabitant. But this involves examining how the American citizen views the question of why there are road crashes at all, who is responsible for them, and how these can best be prevented. This is a study of the safety culture of a country. Then, as in the SUNflower project or via the so-called US scanning tours, benchmarking can be used to discover where the improvement possibilities lie. This benchmarking should concentrate on "how to do?" and not on "what to do?" Such discussions are still going on in the Netherlands. Although road traffic in the Netherlands is relatively safe, we do not regard it as being safe enough.

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Biographical statement

Fred Wegman has been managing director of the national Institute for Road Safety Research SWOV in the Netherlands since 1999. Previously, he served as research director of SWOV. He has authored numerous scientific articles and reports, conference presentations, and seminars. His areas of expertise include developing road safety strategies and implementation programs, as well as road safety research programs and evaluation studies on various road safety topics. He is co-editor of *Advancing Sustainable Safety* (2006), the Dutch vision on road safety.

Fred Wegman has been the coordinator of grants and contracts of several European research projects. He is a member of several international committees, including the Joint Transport Research Centre of the OECD/ECMT, the European Transport Safety Council, and the Board of Forum of the European Road Safety Research Institutes, FERSI. He lectures on road safety at the Delft University of Technology, and is associate editor of the journal *Safety Science*. He is advisor on road safety to Dutch Parliament and the Dutch government, the European Commission, and many countries around the world. Fred Wegman has a masters degree in civil engineering from the Delft University of Technology.