Final report for publication

Promotion of mobility and safety of vulnerable road users

P R O M I S I N G

Promotion of Measures for Vulnerable Road Users
Contract No. RO-97-RS.2112

Final report

Contribution of:
SWOV Institute for Road Safety Research, the Netherlands

July 2001

THIS PROJECT WAS FUNDED BY THE EUROPEAN COMMISSION DGVII UNDER THE TRANSPORT RTD PROGRAMME

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Project Co-ordinator: SWOV Institute for Road Safety Research, the Netherlands

Partners:

BASt -	Bundesanstalt für Straßenwesen, Germany
CERTU -	Centre d' Etudes sur les Réseaux, les Transports l'Urbanisme et les Constructions Publiques, France
ENFB -	Echte Nederlandse Fietsersbond, the Netherlands
I-ce -	Interface for cycling expertise, the Netherlands / United Kingdom
IfZ -	Institut für Zweiradsicherheit e.V., Germany
INRETS -	Institut National de Recherche sur les Transports et leur Sécurité, France
KfV -	Kuratorium für Verkehrssicherheit - Institute of Traffic Psychology, Austria
NTUA -	National Technical University of Athens, Greece
SNRA -	Swedish National Road Administration, Sweden
TRL -	Transport Research Laboratory, United Kingdom
VTT -	Technical research Centre of Finland, Finland
VV -	De Voetgangers-Vereniging, the Netherlands

Sub-contractors:

TØI -	Institute of Transport Economics, Norway
UdB -	Università Degli Studi di Brescia - Dipartimento di Ingegneria Civile, Italy
UNIROMA -	Università Degli Studi Roma Tre - Dipartimento di Progettazione e Scienze dell'Architettura, Italy

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Notice to the reader

This volume is the main report of the European research project PROMISING, on the promotion of mobility and safety of vulnerable road users. The research was carried out by a consortium of European partners, which was co-ordinated by the SWOV Institute for Road Safety Research.

This main report of the PROMISING project is written and edited by SWOV, based on the contributions of the various authors of the six deliverables. These deliverables were not re-edited, but are published in the form in which they were furnished by the authors. SWOV is not responsible for the contents of deliverables that were produced by authors outside SWOV.

Copies of the following PROMISING publication can be obtained by contacting the respective author, or by downloading them from the SWOV website www.swov.nl.

Final report for publication
Promotion of mobility and safety of vulnerable road users. Final report of the European research project PROMISING. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Deliverable 1
Measures for pedestrian safety and mobility problems. Final report of workpackage 1.
NTUA National Technical University of Athens, Greece.

Deliverable 2
Measures to promote cyclist safety and mobility. Final report of workpackage 2.
VTT Technical Research Centre of Finland, Espoo, Finland.

Deliverable 3
Integration of needs of moped and motorcycle riders into safety measures. Final report of work-package 3. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Deliverable 4
Safety of young car drivers in relation to their mobility. Final report of workpackage 4.
BASt Bundesanstalt für Straßenwesen, Bergisch-Gladbach, Germany.

Deliverable 5
Cost-benefit analysis of measures for vulnerable road users. Final report of workpackage 5.
TRL Transport Research Laboratory, Crowthorne, United Kingdom.

Deliverable 6
National and international forums to discuss the approach and the results of PROMISING. Final report of workpackage 7. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Leaflet
Integrated planning for mobility and safety is promising. Leaflet on the European research project PROMISING. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

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Partnership

The PROMISING project was carried out by the following consortium:

Project co-ordinator

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Contractors

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Executive summary

Aim and approach

This final report of the PROMISING project integrates the findings of the work of six workpackages. The reports of these workpackages are available separately. The final report selects main findings of the different workpackages and combines the results as much as possible. The report is policy-oriented and illustrated with photos and clear examples, in accordance with the requests of EU DGVII, the commissioner of the project.

The aim of the PROMISING project was to develop measures that reduce the risk of injury to vulnerable and young road users as much as possible in a non-restrictive way. That is to say that safety and mobility must be improved together; the improvement of safety should not take place at the cost of reduced mobility.
The potential for problem reduction was specified for four target groups: pedestrians, cyclists, motorised two-wheelers (i.e. motorcyclists and riders of mopeds) and young car drivers. The aim was to present measures within an implementation framework, with the main focus on technical, non-restrictive aspects. The differences between European countries in their transport modes were taken into consideration.
In order to determine the potential for problem reduction, available data and expertise of the following subjects were studied and combined:

- safety problems,
- task requirements,
- measures related to problems and tasks,
- effects of measures on safety and on mobility,
- costs of measures.

The research consists of six workpackages. The first four workpackages each focused on one of the target groups. The research approach between the packages varied.
Since there is a lack of planning for the mobility of pedestrians and cyclists, the research approach in the workpackages on these subjects was to take walking and cycling as modes of transport in their own right, and consequently to combine transport criteria with safety criteria.
The research approach for the motorised two-wheelers and young drivers differed from this, because of the high risk of these modes in relation to the high speed and complex driver task. In these workpackages, the most important safety measures were selected and subsequently mobility aspects were integrated.

The PROMISING project paid much attention to the effectiveness of measures. Calculations of the costs and benefits of a selection of measures were needed to compare the different measures. Workpackage 5 described the technique and application of cost-benefit analyses and calculated the costs and benefits of 20 measures selected by the other workpackages.
The points of view of road users and their own experiences were also considered in the comparison of the measures. For this reason, an international forum of interest groups was consulted during the project. In four countries, a national forum with representatives of governments and

interest groups was asked for their opinions. These consultations are coordinated in WP6.

In this current report, the most important results and conclusions of the six workpackages are discussed.

Analysis and main conclusions

The analysis of the safety problem shows that in Europe as a whole, the risk of a fatal accident per kilometre travelled is highest for riders of motorised two-wheelers. Young car drivers have a higher risk of a fatal accident per kilometre travelled than pedestrians and cyclists of the same age do. The risks for pedestrians and cyclists do not differ significantly. However, the risk of a fatal accident per kilometre travelled for different modes, varies tremendously from country to country. This could be due to national and local conditions.

Cycling in Raalte, the Nether-lands.

"Cycling in Schwerte ... earlier at your destination"(Germany).

An important subject in the study was to consider in what way safety problems of pedestrians, cyclists and motorised two-wheelers might be related to the fact that these modes are not integrated automatically in the planning for traffic and transport in Europe, whereas those of car drivers are.

The favouring of cars as a mode of transport in planning and infrastructural design over other modes has its roots in the 1960s and 1970s. This period was marked by rapid increase of car ownership. Car transport was given priority over other modes in transport planning. One consequence of this is that in the framework of safety policies, a curative approach (to protect other modes to the threats by cars) is currently promoted that may restrict the mobility of the pedestrians, cyclists and motorised two-wheelers. In fact, it is explicitly recommended to not promote cycling, for example, as long as certain safety measures have not been implemented.

A new mentality towards non-motorised transport emerged in the 1980s, when the growing negative impact of motorised transport, such as pollution, noise and space requirements, became noticeable. From then on, it became important to reduce both the need for travelling large distances and the share of car use. In the PROMISING project, travelling was therefore not considered as a goal in itself, but as a means for participating in society (going to work, shopping, visiting friends et cetera). Also, the possibilities of different transport modes in fulfilling the mobility needs of different target groups (including elderly and children) have seriously been considered.

Although the opportunities and benefits of non-motorised transport are receiving an increasing amount of interest, there is no balance in planning and design between motorised and non-motorised transport. In the PROMISING project, planning and design principles have been reviewed critically for their implications on infrastructural facilities for the four target groups (cyclists, pedestrians, motorised two-wheelers and young car drivers).
The main conclusions of the problem analysis are given below.
A shared conclusion for walking and cycling is that the design of road facilities generally is not, but should be, directed towards their safety and mobility needs. These needs concern a coherent network, direct routes to destinations, safety, comfort, easy task performance and attractiveness. To consider walking and cycling as a means of transport requires a change of thinking on the political level. If the safety and mobility of all groups are to be enhanced in an integrated way, a better balance in mobility and safety for all modes of transport must be created. Modes that will be promoted will be subject to higher quality requirements and to fewer restrictions. Political interventions are needed to achieve this, and road users ask for this change. Several studies (e.g. the SARTRE-survey, 1998) show that more people ask for high planning priority for walking and cycling than for car driving. However, the various (competing) needs and interests of all citizens, road users and interest groups (such as shopkeepers) must all be taken into account when selecting measures. Policy implementation should therefore also focus on conflict management and on balancing the different interests and needs.

The project also showed that the needs of riders of motorised two-wheelers do not receive priority in road design, either. It is generally not recognised that design criteria for motorcycle/moped riding should be different to those applied for driving in cars. The riders are much more vulnerable to imperfections of the road surface than car drivers, and special requirements must therefore be made recognised for road markings, road surface repairs, longitudinal grooves, drainage et cetera.

The actual priority treatment for cars implies that the needs of young drivers are already catered for regarding the planning and design of infrastructure. The safety problems of young drivers and riders of motorised two-wheelers indicate there is a need for improved education in combination with behavioural restrictions. A graduated licensing system for car drivers is necessary. Young people should not only rely on riding and driving by themselves to fulfil their mobility needs. This entails that in the case of young drivers and riders of motorised two-wheelers, a non-restrictive approach will not be sufficient to solve road safety problems.

A common need for all groups is education that focuses on a considerate and respectful attitude towards other road users.

Cycling in Paris, France.

The way forward: combining long-term planning and short-term measures

The analysis indicated the main problems for the for target groups that need to be addressed to improve road safety. In order to make the recommended safety measures work, the following conditions should be made:

- Walking and cycling need to be recognised as transport alternatives in their own right.
- The needs of motorised two-wheelers need to be integrated in the design of safety measures for motorised vehicles, because their needs may conflict with those of cars and heavy vehicles.
- For young drivers, a graduated system for drivers' licences needs to be introduced, and the use of cars should be limited.

This way, the safety of the four groups can be increased significantly while it allows people to choose more freely between the different options for modes of transport to satisfy their mobility needs.

Evidently, long-term planning is needed to create the fundamental changes that will improve the safety and mobility of vulnerable road users. Measures require a framework that takes the various needs of vulnerable road users into account. The rapid growth of mobility along with the impact of traffic on livability and the environment also necessitates long-term planning.
Yet, this does not mean that it is impossible to achieve results in the short term, as progress is already being made. The provision of an integrated network for pedestrians and cyclists is a gradual process that has already started. It requires that these groups of road users be given more priority in planning and road design. At crossings in urban areas all over Europe, the conditions for safety and efficiency for pedestrians and cyclists are improving.

Long-term planning is also needed if real progress is to be made in the field of road safety.

New concepts provide the framework that long-term planning requires. These concepts stop defining road fatalities as a negative, but largely accepted side-effect of the road transport system. Rather, road fatalities can and should be avoided, and the probability of accidents can be reduced drastically by means of the infrastructure design. And where accidents still do occur, the process which determines the severity of these accidents should be influenced in such a manner that the possibility of serious injury is virtually eliminated.
The Dutch concept of Sustainably Safe Traffic and the Swedish 'Zero Vision' concept both aim at reducing fatality risk, and are examples of new approaches towards road safety and road accidents. The Dutch system is currently characterised by:

- a structure that is adapted to the limitations of human capacity through proper design, and in which streets and roads have a neatly appointed function, as a result of which improper use is prevented.
- vehicles which are fitted with facilities to simplify the driver's tasks and which are designed to protect the vulnerable human being as effectively as possible.
- road users who are adequately educated, informed and, where necessary, guided and restricted.

A road safety system based on this framework can be combined with transport policies that consider walking and cycling as a mode of transport. This approach can be implemented gradually.

The main consequences of the necessary framework and new concepts for road planning and design are:

- Motorised traffic with a flow or distribution function must be segregated from non-motorised transport.
- A network of main traffic routes must be created for pedestrians and cyclists.
- A fair balance between motorised and non motorised traffic for priority facilities at crossings should be achieved.
- The maximum speed of motorised traffic should be limited on roads where it mixes with non- motorised traffic.

Main measures per group

The measures that were suggested for each target group are discussed in this section.

Pedestrians

Of the pedestrian safety measures considered in the report of WP1, the following two are the most comprehensive and most closely associated with urban planning and policy philosophies:

1. area-wide speed reduction or traffic calming schemes;
2. the provision of an integrated walking network.

These are two complementary measures, which can be taken simultaneously without conflicting. Not only do they apply to different parts of the urban fabric, but they also address different objectives. Area-wide schemes (the most widespread of which is the 30 km/h zone) are aimed at reducing vehicle speeds and thus at allowing for a safer mingling of pedestrians with motor traffic. Integrated walking networks (usually centred around a downtown pedestrian zone) serve to remove and/or reduce conflicts between pedestrians and vehicles and to provide or improve crossing points.

In addition to road and traffic planning and management, there are other measures that could improve the safety of pedestrians. Vehicle users must be made to accept pedestrians as road users equal to themselves, to know the rules and regulations that protect pedestrians, and to observe pedestrian rights. To some extent, adequate road and traffic management contributes to the achievement of the behaviour expected from drivers. Other measures (education, information, enforcement) are usually needed to achieve the right balance, and additional incentives may be found in areas other than mobility and safety. One example of such an additional incentive would be preoccupation with the environment.

Walking in Delft, the Netherlands.

Both the requirements that pedestrians' movement patterns create for traffic planning and traffic management and the design of roads and their environment are summarised in chapter 5 of this report. Approximately 100 measures have been reviewed with regard to their safety and mobility effects and their costs.

Cyclists

The same basic planning principles that apply for pedestrians apply for cyclists. Because cycling is suitable for travel over greater distances than walking, it is necessary to distinguish a flow and an access function. As is the case with motorised traffic, a network for the flow function is required. However, this network cannot follow the network for through-motor traffic easily, since the mesh of the routes of the cycling network is smaller. Provisions for cycling should therefore not simply be seen as additional features of the traffic structure for motor traffic. Rather, they require a network of their own.
In addition to this, technical requirements to be met by bicycles and by other vehicles in connection with the safety of cycling are reviewed. Reliable and easily maintainable devices for bicycles make the requirements less restrictive, because if the devices do not work properly or have to be repaired, the bicycle will be used less. Injuries to cyclists and pedestrians may be reduced by a better design of cars and heavy vehicles.

Utrecht, the Netherlands.

A hierarchy of roads was developed according to function, design and behaviour for all modes of transport (based on the Dutch Sustainable Safe traffic System and the Swedish Zero Vision concept). It was based on the requirements of coherence of the network, directness, safety, comfort and attractiveness on the one hand and on the new concepts for road safety in the Dutch sustainable traffic system and the Swedish Zero Vision on the other hand.
The hierarchy was developed only for built-up areas and comprises 5 types:
1. through-traffic route with a speed limit of 70 km/h and only grade-separated crossings;
2. main street or urban arterial road with speed limit of 50 km/h and, in some areas, 30 km/h;
3. residential street with a speed limit of 30 km/h;
4. walking-speed street;
5. car-free areas for pedestrians and cyclists.

Further main principles for road safety and transport education and driver instruction are presented in the report of WP2.

Motorised two-wheelers

The report of the workpackage regarding motorised two-wheelers emphasises that road authorities must be made aware of the fact that riders of mopeds and/or motorcycles are much more vulnerable to imperfections of the road surface than car drivers are. Special requirements must be recognised for road markings, road surface repairs, longitudinal grooves, drainage et cetera. The same applies to the design and location of guard rails, which may add to the injuries of riders when they collide with the rails. Furthermore, speed-reducing measures like humps may pose special problems for mopeds/motorcycles. However, speed reduction measures must also be reviewed to guarantee more strongly that riders of motorised two-wheelers keep to the limit.
A better consideration of the needs of motorised two-wheelers fits in with a non-restrictive approach.

Special traffic rules, such as those allowing motorbikes to overtake slow moving lines of cars and allowing for them to ride on lanes with limited access, may give riders of motorcycles/mopeds some privileges compared to car drivers. This requires that decisions about the position of motorised two-wheelers in traffic management be made on a political level.

Furthermore, more empirical information is needed on the effects of such special rules.
The perception of mopeds/motorcycles is a special problem for other road users. This problem can only partly be solved by the use of daytime headlights by riders of mopeds/motorcycles. Car drivers must be made aware of the need to look out for mopeds and motorcycles and to learn to anticipate on their presence.

Training and experience are important factors if riders are to be able to control the moped/motorcycle in all kinds of situations, to cope with imperfect road surfaces and obstacles on the road, to recognise situations in which other road users may not react adequately to their presence, and to understand the consequences of behaviour which is different from that of car drivers as well as how to cope with these consequences. Countries with a relatively low minimum age for riding a moped or without compulsory training or licensing should reconsider their regulations. Low-speed mopeds with lower requirements could also be considered in these countries.

Vehicle improvements to the motorised two-wheelers could be restrictive, because they may add to the costs of riding. In some countries, mopeds are tuned to make them go faster. This is a serious safety problem, since their riders are not properly prepared for these higher speeds. But, within limits, rider motivation and riding style have more effect than vehicle characteristics on accident rates.
The lack of protection of riders of mopeds/motorcycles can only partly be compensated for by wearing a helmet or other protective clothing. Wearing helmets is compulsory for motorcyclists in all European countries. Actual wearing rates may be close to 100%, with the exception of a few countries in Southern Europe. However, helmets are not always worn correctly, which may greatly reduce their protective effect.

Young drivers

The measures recommended for young drivers are in general restrictive regarding the options for behaviour. Lack of skill, inexperience, high exposure to difficult situations, and willingness to take risks are the main reasons why young car drivers face problems different to those of other car drivers.

Reduced car use is possible and has a positive result. Evaluation studies show that alternatives such as disco buses and cheaper public transport have a positive effect on road safety figures. If alternatives for car use are brought into line with the specific mobility needs of young people, the restrictiveness may be limited. In the search for attractive measures, a social marketing approach is required.
Another measure that would reduce car use by young people and thus lower the mortality rate would be to raise the minimum age for driving. However, it is also important to extend the learning phase as inexperience contributes greatly to the high accident rates of young drivers. A solution would be to introduce a graduated licensing system in which the learning period is extended. This can be achieved by lowering the minimum age for starting the training, while the minimum age for obtaining a licence remains the same.
The licence system could also be turned into an intermediate system, in which the full licence can only be obtained if the driver stays violation-free or observes restrictions such as accompanied driving, night curfews or a lower alcohol limit. A second test after probation could be added to this, to motivate drivers to gain experience and not to simply refrain from driving.

Although the behaviour in respect of drinking and driving by young drivers is not worse than that of older drivers, drinking and driving is a very serious problem, because young drivers are more exposed to alcohol during weekend nights. A lower legal limit for alcohol consumption in relation to driving is recommended in combination with certain social and economic measures.

Improvement of education and instruction is a possible, non-restrictive measure. Driving simulators are a technical means which provides good opportunities for improving the education. Hazard perception training is also effective, but the training of appropriate driving skills may result in a negative effect: the overestimation of abilities which leads to higher accident rates.
However, the problem analysis also makes clear that personality traits are influential for about 30% of the target group. They demand other intervention strategies, which may start at an earlier age.

Technical measures that involve limitations to the car, are at present still a theoretical option. The application of Intelligent Transport Systems could provide solutions, but the actual development of such instruments is not primarily motivated by safety.

Costs, benefits and effective measures

Because the costs of measures are often tremendous, there is an increasing demand for information about the relationship between the costs and benefits of these measures. Furthermore, there are many competing demands from society for improving the standard of living, for social activities and for preservation of the environment and the cultural heritage.

In the PROMISING project, the methodology of the cost-benefit analyses is described and the cost-benefit ratios of 20 measures are calculated. The calculations were made for single measures only, as it is very difficult to get good data on the exposure and risk of injury for each mode of transport and, related to this, of the effects of measures on travel efficiency and safety. Only those measures of which the effects are well-known, and only situations in which policy requirements and objectives are clearly articulated and widely supported were assessed for their cost-benefit ratio, since monetary values had to be assigned to the effects. These considerations limited the selection of measures for the analysis.
The analyses presented are in most cases based on data from one country, which also limited the selection of combinations of measures.

A methodological problem exists in the case of cost-benefit analyses for measures controlling car traffic. Measures that reduce motor traffic, either by raising the direct costs or by slowing traffic down, will often fail a cost-benefit test because the methodology is biased in favour of the amount of kilometres travelled. In this sense, cost-benefit analyses can hardly be said to be neutral with respect to long-term policy objectives. Reduced cost and increased demand always count as a benefit in cost-benefit analyses, whereas a reduction in demand (ceteris paribus) counts as a loss of benefit. Policies that aim to reduce travel demand by a particular mode of transport are very difficult to justify by means of cost-benefit analyses. Yet it may be precisely such, restrictive, policies that are needed in order to promote a sustainable transport system.

Emmen, the Netherlands.

Amsterdam, the Netherlands.

Cost-benefit analyses are a subject of new projects in the fifth framework for EU research. The results from the PROMISING project show that there clearly is a need for a review of the input of these analyses.
Cost-benefit analyses were made of the following measures for improving the safety and mobility for vulnerable and inexperienced road users:
- roundabouts;
- road lighting;
- integrated area wide urban speed reduction schemes;
- environmentally adapted through-roads;
- upgraded pedestrian crossings;
- parking regulations;
- front, side and rear underrun guard rails on trucks;
- local bicycle policies to encourage mode switching from car driving;
- bicycle lanes;
- bicycle paths;
- advanced stop lines for cycles at junctions;
- mandatory wearing of bicycle helmets;
- improved bicycle conspicuity;
- daytime running lights on cars;
- daytime running lights on mopeds and motorcycles;
- mandatory wearing of helmets for moped and motorcycle riders;
- design changes on motorcycles;
- graduated licensing – lowered age limit for driver training;
- license on probation – lowered BAC-limit for novice drivers;
- disco buses.

A generalisation of the results leads to the following conclusions:
- Measures that *reduce driving speed*, especially in urban areas, will improve safety, and sometimes mobility, for pedestrians and cyclists. However, more kinds of benefits must be included in the analysis, such as social safety, mobility opportunities for children, elderly and handicapped people, as well as the city and residential climate.
- The benefits of *facilities for pedestrians and cyclists* exceed their costs by a wide margin.
- Measures that *improve conspicuity and visibility* of road users are cost-beneficial.
- The implementation of measures regarding *injury protection*: underrun guard rails on trucks and helmet wearing for motorised two-wheelers are cost-beneficial.
- *Graduated licensing* and *driver's licence on probation, including a lower BAC limit of 0.01%*, are promising measures for inexperienced drivers.

When the results of the cost-benefit analyses are combined with the recommended measures from the reports on pedestrians, cyclists, motorised two-wheelers and young car drivers, and when it is taken into consideration that only isolated measures could be included in the cost-benefit analysis, the following 10 measures can be said to be the most important according to the PROMISING-project:

1. a separate network of direct routes for pedestrians and a separate network of direct routes for cyclists;
2. transport alternatives for young drivers, such as disco buses;
3. a categorisation of roads to separate flow traffic from distribution traffic and access traffic;

4. area wide speed reduction apart from roads with a flow function for motorised traffic;
5. infrastructural design standards for pedestrians, cyclists and motorised two-wheelers: implementation (and development);
6. priority rules and regulations for cyclists and pedestrians in urban areas and technical measures that support priority and stimulates perception and anticipation;
7. privileges for motorised two-wheelers in relation to car drivers;
8. a graduated or intermediate licensing system for young car drivers and motorised two-wheelers;
9. education that focuses on a considerable and respectful attitude to other road users;
10 injury protection by design of cars and heavy vehicles.

Implementation: recommendations

The following considerations for implementation of measures can be presented.

Although single measures may be effective, isolated safety measures of one single type do not, in general, go very far in reducing safety and mobility problems. It is considered more advisable to aim for balanced and comprehensive solutions rather than to seek a one-to-one relationship between one problem and one countermeasure. Therefore, packages of several measures should be implemented.

Implementation of a good proportion of the safety measures applied in urban areas requires co-operation between authorities on all levels. It requires cooperation between local authorities and the national government or administration, as the central administration may provide support to the local initiatives (through regulations, incentives, expertise, follow up and information gathering) in many cases. Conversely, local initiatives may complement national action and give it more prominence on the local level (in safety campaigns, educational issues, et cetera).
The international level cannot be disregarded. The EU could harmonise technical requirements for vehicles and licensing systems, for example. Perhaps highway codes can also be reviewed for harmonisation to a certain extent. Regarding infrastructural facilities and design, the EU can support good local initiatives by rewarding a recommended approach with subsidies.

Target setting is a good way of establishing what has to be done to plan for the future. It makes clear what kind of resources we need to bring in, what kind of tools are needed for good planning, and it directs our activities towards looking for an effective and efficient approach.
Setting targets and planning cannot be fruitful without monitoring success and failures.
Monitoring is an instrument to adapt policies when they are not as effective as planned, to remain flexible because external factors may change, and also to keep all parties alert and involved. Showing progress is of course a very important stimulus for continuation of a policy.

A key recommendation for all groups is to involve the road users or their representatives in the planning process. The analyses made clear that their needs have not been taken into account in the planning and the design of facilities. The best means for determining whether measures will work and whether they will provoke a good use of facilities and the right behaviour is involvement of the road users. Because of the mobility needs of society and their economic function, and because of the impact of traffic on other use of space, the social climate and the environment, it is also important to involve communities and different interest groups in the design of the transport and traffic system.

Development of expertise and training is an important precondition for the development of effective policies, both in government and the private sector. Three aspects need to be addressed.
Firstly, to make sure that those coming into the profession fully appreciate both the policy needs and all the practical necessities of planning for different groups of road users.
Secondly, to ensure that those already in the profession maintain their skill levels and keep abreast of the latest developments. Best practice can change very quickly.
Lastly, there is a need to raise the status of those in the profession so that good-quality people are tempted to come into the profession in the first place, and to stay in it, knowing that they have sufficient chances for promotion.

More general recommendations can also be deduced from the PROMISING project. Progress in the fields of transport and traffic can be promoted by an exchange of expertise and experiences. An exchange of expertise and experiences is most helpful when it guides process-related thinking. It is impossible to copy solutions from one country to another and even from one city to another. Principles and guidelines can help the parties involved in finding solutions in their own context. Training is a precondition for progress and should be directed to process-related learning. Good examples should provide further inspiration and demonstrate the attractiveness of solutions.

In summary, it can be said that the context, that is the transport, political, technical, economical and cultural environment, will determine which solutions fit best locally, regionally and nationally. Principles can be applied but must be transformed into concrete measures.

To conclude

For walking and cycling, safety problems have a direct relation with the absence of a mobility policy. The recognition that walking and cycling are means of transport opens up a wide variety of measures with a high potential for safety improvement. The possibilities for promotion of walking and cycling by fulfilling requirements such as comfort, direct access, priority and safety, shows that there is no need to limit our perspective of walking and cycling to problem aspects.

Acknowledgement of walking and cycling as means of transport however, asks for a fair balance between the interests of different modes of transport, limiting the threat that motorised vehicles pose to walking and cycling. Categorisation of roads and traffic calming provide a good framework for this.

The positive margins between benefits and costs for these kind of measures are also wide. Other benefits of walking and cycling, such as health, a pleasant city and a residential climate for leisure, recreation and shopping, further support the notion that these modes of transport should receive more priority. This is also the case when such disadvantages of motorised traffic as pollution, noise and space requirements are considered. A safety policy for pedestrians and cyclists is most effective when it is combined with a mobility policy and therefore is non-restrictive in its nature.

For motorised two-wheelers and young drivers the situation is different. The risks involved with riding motorised two-wheelers are high on average. Sub-groups of young drivers also have a very high risk. While a non-restrictive policy for motorised two-wheelers can decrease safety problems, the problems cannot be solved sufficiently by such a policy. Yet, it remains important that the special needs of motorised two-wheelers are taken into consideration to a greater extent, for example in the design of road infrastructure.
A non-restrictive policy for young drivers implies that transport alternatives be developed to cater for their mobility needs.
A restrictive policy for both motorised two-wheelers and young drivers is needed, which means age limitations and full licensing limitations. Furthermore, speed control and injury protection measures are necessary. Thus, for these target groups, a safety policy cannot possibly be entirely non-restrictive.

From the abovementioned conclusions of the PROMISING project, two recommendations for further research seem to be most important.

1. The absence of explicit policies for various modes of transport entails that criteria must be developed to cater for the needs of their users. The current criteria for traffic flow, right-of-way regulations and the like must also be reviewed. Several countries have already developed manuals for a better planning of cycling, outlining basic principles and presenting design alternatives. Much can be learned from the expertise and experiences in developing solutions adapted to other national and local situations with a different transport and traffic history.

2. Cost-benefit analyses could support the selection of priority measures. However, a more solid basis is necessary for taking the various kinds of benefits of traffic and transport policy alternatives into account, and must be developed. Current data for cost-benefit analyses are mainly determined by the amount and speed of motorised traffic.

The measures presented in this report are sufficiently PROMISING for safety improvement to justify adoption of the approach for a better balance in planning and investments for all modes of transport.

1. Introduction

In 1997, the Directorate General for Transport DG VII of the EU asked for proposals concerning the 'Development and Promotion of Measures to Reduce the Risks of Injury to Vulnerable Road Users and Inexperienced Drivers and Riders'. The objective of the project is to capitalise on technical developments and to show the potential for problem solving through non-restrictive measures. To integrate the objectives in the subject, this project is about:

The development and promotion of non-restrictive technical safety measures for vulnerable road users and inexperienced drivers and riders

A consortium coordinated by the Dutch SWOV Institute for Road Safety Research put forward a project plan. The project was referred to as PROMISING (development and PROmotion of measures for vulnerable road users with regard to Mobility Integrated with Safety taking into account the INexperience of the different Groups). This proposal was accepted and the work started on January 1st, 1998.

The potential for problem reduction was specified for four categories of road users: pedestrians, cyclists, motorised two-wheelers and young car drivers. This potential for problem reduction is based on combination of data and expertise with regard to safety problems, task requirements, measures related to problems and tasks, effects of the measures on safety and mobility and data on costs of measures.

For assessment of the restrictiveness of measures, experts and representatives of road user groups were involved. Measures were also considered in an implementation framework. Consideration was given to differences between European countries in the share of different transport modes.

Six workpackages (WP's) were created for the execution of the research.
WP1 produced a report concerning *pedestrians*, coordinated by NTUA, the University of Athens, Greece.
WP2 produced a report concerning *cyclists*, coordinated by VTT, Finland.
WP3 produced a report concerning *motorised two-wheelers*, coordinated by SWOV, the Netherlands.
WP4 produced a report concerning *young car drivers*, coordinated by BASt, Germany.
WP5 produced a report concerning *cost-benefits of measures*, coordinated by TRL, United Kingdom.
WP7 dealt with the *dissemination of the results*, coordinated by SWOV, the Netherlands.

The common approach in WP's 1 - 4 was to present safety measures as much as possible in a non-restrictive way. Each WP analysed safety problems, made an inventory of measures and evaluated restrictiveness, costs and benefits of the measures. But the approach differed in some respects. The WP's concerning pedestrians and cyclists started by taking walking and cycling as a mode of transport and combined this with safety criteria. The WP's concerning motorised two-wheelers and young drivers selected the most important safety measures and combined this with a mobility approach.

WP5 described the technique and application of cost-benefit analysis and calculated the costs and benefits of measures selected by the other WP's. Much attention has been paid to the availability and reliability of mobility and exposure data.

In this Introduction chapter, an explanation will be given of the approach of the project.

1.1. Safety in a non-restrictive way

The aim of the project is to improve the safety of vulnerable road users in a non-restrictive manner. This means that road safety measures for these road users must not be at the expense of their mobility.

The background to this request by the European Union is that safety policy has been developed more or less independently of transport policy. Especially for pedestrians and cyclists, many safety measures have been restrictive in the past. Priority has been given to smooth car traffic. Pedestrians and cyclists have had to give up space and freedom and still are vulnerable when they share the road with motor traffic.

The question is thus: in what way can we promote safety while taking into account the mobility needs of all the different groups of road users?

The European car drivers also wish for the creation of a better position for other modes than the car. SARTRE, a survey of car drivers conducted in 19 European countries in 1997 showed that 51% of car drivers think that "very much consideration should be paid to cycling when planning for the future", and 50% feel the same consideration should be paid to walking. Only 37% of the car drivers were of the opinion that "very much consideration" for cars is needed (Cauzard & Wittink, 1998). One may assume that priority for cycling and walking would be rated even more highly if all road users and not only car drivers were involved in the SARTRE project.

What do we mean by restrictiveness?
A measure is regarded as restrictive under the following conditions:
- *It reduces the opportunities for travel*, for example by prohibiting driving at certain times (for example, night-time curfews for young and inexperienced drivers),
- *It restricts the choice of mode of travel*, for example by banning the use of a certain type of vehicle (for example, banning certain types of motorcycles),
- *It prolongs travel time*, for example by imposing additional waiting time at crossing facilities (for example, a vehicle actuated traffic signal may impose longer delays on pedestrians waiting to cross a road),
- *It requires pedestrians and cyclists to adapt to motor traffic,* for example by imposing detours or restricting the use of traffic lanes (for example installation of safety fences at pedestrian crossings),

- *It otherwise increases the cost of travel*, for example by requiring the use of protective devices (for example making the wearing of cycle helmets mandatory).

Figure 1.1. *Restrictive measure in Helsinki, Finland*

Of course, all road users are subjected to restrictions - no human society can exist if people do not accept any restriction. Freedom should always be limited where it starts to affect the freedom of others. Basically, restrictions are acceptable as a means of achievement of a fair or proper balance of interests.

But as far as the traffic and transport system is concerned, the existing balance of interests between different categories of road users is neither fair nor proper. Moreover, the massive use of motorized modes has a number of side-effects relating to the environment and liveability. And on top of this, it seems that the transport system is becoming more and more inefficient, creating its own inaccessibility.

Given the above, the assessment of the restrictive nature of specific measures can be a relative assessment. Accordingly, the PROMISING project was directed at the development of measures that result in a better balance between all modes of transport regarding safety and mobility.

The best manner to establish the ways in which safety and mobility are excessively in conflict with each other is to analyse the needs of all modes of transport. Moreover, a segmentation of groups according to e.g. age and handicaps is necessary. Criteria for favourable conditions for travel are:

- *Safety:*
  Aspects are the prevention of collisions with other road users or obstacles, and security or social safety, i.e. the prevention of being attacked while walking or cycling.

- *Coherence of infrastructure facilities on the road:*
  Aspects for coherence are: continuity, consistency of quality, recognizability, and completeness of bicycle facilities.
- *Directness:*
  Aspects are mean travel time, detours, and delays.
- *Comfort:*
  Aspects are smoothness of road surface, curves, gradients, number of stops between origin and destination, complexity of rider's task.
  Attractiveness:
  Aspects are visual quality of the road, surveyability, and variety of environment.

Figure 1.2. *Bicycle facilities in Utrecht, the Netherlands.*

Application of these criteria to all categories of road users requires a critical evaluation of the current design of the traffic and transport system. If the needs of all groups of road users are to be accommodated, the criteria used in traffic and transport planning, which focused primarily on the needs of cars, must be reviewed. Criteria for flow, accessibility, capacity, and the like, must be differentiated for the different modes, and maybe also for types of trips.
Moreover, current policies tend to promote a shift in the use of modes towards non-motorized transport and public transport. The consequence of this may be that modes to be promoted will be subject to higher quality requirements and to fewer or less severe restrictions.

It is obvious that a measure that is non-restrictive for one group may be restrictive for another, and this is particularly true if a better balance of priorities of different modes is sought.

Apart from this, these contradictions are relativized somewhat if we consider non-restrictiveness in relation to mobility and not in connection with a certain mode. There are many people in Europe who do not have the possibility of using a car. If walking is restricted, the mobility of these people will be restricted. A car driver may have alternatives, and research has shown (e.g. WALCYNG) that many journeys done by car could be done using other modes of transport. The challenge is to find attractive ways to fulfil the mobility needs of all people and to present alternatives that accommodate a huge variety of demands.

Moreover, road users have more interests than only transport. The relation between traffic and accessibility, residential climate, local economy, safety and security, health, and the environment are very important. The PROMISING project cannot deal with all the issues, but the recommendations have been developed in a broader perspective than transport and traffic alone.

The measures for the four groups should be as non-restrictive as possible, but they must of course have a positive effect on safety. There may thus be no alternative to restrictive measures if a positive effect on safety is to be achieved.

1.2. The development of measures

For the development of measures, the PROMISING report capitalises on the experiences and expertise with road safety measures in European countries.

Europe in the 20th century has developed a great number of road safety measures. The development took off during the 1960s when mass-motorization occurred. The need for road safety policy became acute.
The number of road deaths increased every year. Road safety research institutes were founded in various countries for analysis of the problems and development of effective measures.

The exchange of expertise and experience with measures provide a rich basis for future policy. The EU supports such an exchange and, to a certain extent, harmonisation of traffic laws and the standardisation of technical requirements to be met by vehicles, for example. In this way, measures that have proved their value in some countries may be implemented in others.

But the applicability of experiences and expertise has its limitations. Generally speaking, in the past, road safety policies did not take into account the mobility needs of different modes of transport, but took the growth of car traffic for granted. In many countries in Europe, policies are being developed that also regard walking and cycling as modes of transport. The design requirements for efficient transport will have to be developed in an appropriate manner for walking and cycling. Manuals relating to this have been produced in various countries.
A second limitation regards the road safety policy itself. Many measures that have been developed were very successful. But they are not sufficient to create the conditions for a safe road system. The road users should be able to see immediately, from their traffic environment, what behaviour is required, and their behaviour should be technically guided in this direction. The risk of serious injuries should be minimised by a fine tuning of the road design to the limited human capacities. New road safety concepts have been develop to realise this.

The change towards such an inherently safe road system starts on roads and in areas where the biggest problems are experienced. For example, more and more residential areas have a speed limit of 30 kilometres per hour. Residents and pedestrians and cyclists ask for these kinds of measures. Spatial and transport planning together may create a good basis for traffic calming solutions in built-up areas.

The trend for speed reduction has not only been stimulated from the road safety point of view. Road safety can be supported by other interests. It will therefore become more and more necessary to integrate road safety policy with policies concerning transport, traffic management, environmental pollution, urban quality of life, and other social matters, and to analyse the policy context to determine priorities.

The PROMISING project concentrates in this respect more on the implementation of measures than solely on ‘promotion’. Success depends on opportunities to bring about changes in the current practices in relation to political, economic, technological, cultural, and other factors.

This underlines another point regarding applicability of measures. Any policy development is strictly related to the specifications of the road safety problems of a particular country, region or city. The general applicability of a measure's effects must always be tested in the context of actual mobility and safety patterns, the integration with various other relevant policy areas, the political environment, policy organisation, and procedures.

In the PROMISING project, much attention has been paid to the effectiveness of measures. Furthermore, cost-benefit analyses have been performed for a selection of measures. This emphasis on costs and benefits may further increase the application of measures.

1.3. Technical and non-technical measures

The EU emphasised that the PROMISING project should focus on technical measures. On the one hand this is logical. Planning for a means of transport cannot be done without creating the infrastructural facilities on the road itself. It also cannot be done without a network of infrastructural connections between origins and destinations.

On the other hand, it is not correct to contrast technical and non-technical measures as if it were simple to choose between them. Regulations are an important tool for creating favourable conditions for efficient transport. Moreover, if the needs of the road users are to be taken into account, their involvement in one form or the other seems reasonable.

There are various ways in which road users can be involved:

- participation in the policy development, planning process and evaluation of measures and communication about aims for the future and the need for measures,
- education and information to teach road users to make good and proper use of traffic facilities and to inform them about the personal and social advantages and disadvantages of the various modes of transport.

This makes a combination of technical and non-technical measures necessary. Thus the emphasis on technical measures is supported in the realisation of the project. But technical and non-technical measures have different functions and they support each other. The determination of a good mixture depends on the needs of road users.

1.4. The structure of this report

In the next chapters, the summaries of the reports of the six workpackages will be presented. These summaries have been structured according to the approach mentioned in this first chapter. But first, in chapter 2 some main results will be presented from four research projects that have provided a lot of data and information for, in particular, the workpackages on walking and cycling: the EU projects WALCYNG, ADONIS and DUMAS and the OECD report on vulnerable road users.

Chapter 3 reviews the current situation regarding the mobility and safety of the four groups of vulnerable road users. It also describes the main factors of influence for their mobility and safety. Chapter 4 adds information about legislation. Chapter 5 presents an overview of measures to enhance the safety and mobility of the vulnerable and inexperienced road users. Chapter 6 adds to this the results of the cost-benefit analyses. Chapter 7 contains recommendations for implementation strategies and Chapter 8 presents the overall conclusions and recommendations of the project.

2. Results from other research projects

The PROMISING project made use of the work of three other EU projects: WALCYNG, ADONIS, DUMAS, and of the OECD report on vulnerable road users.

In this chapter, the main elements of the projects will be described. They all refer to walking and cycling.

2.1. Aims and approach

WALCYNG and ADONIS both addressed the possibilities for replacing car trips with walking and cycling and at the same time make walking and cycling safer. DUMAS has Urban Safety Management as its subject and focuses on the safety of pedestrians and two-wheelers. The OECD report describes problems and solutions for the road safety of pedestrians and cyclists.

WALCYNG was strongly marketing-oriented. The approach consisted of four steps: to collect information about potential and practising customers (road users); to devise attractive solutions; to inform the users that their needs and interests have been taken into consideration; and to provide incentives given by society, institutions, companies etc. Only the combination of the four elements will guarantee a change in travel behaviour. This work lead to an evaluation scheme: the WALCYNG Quality Scheme.

ADONIS analysed the reasons behind people’s choice of mode of transport, and also cyclist and pedestrian accident factors. Three cities, Amsterdam, Barcelona, and Copenhagen, were compared. This made it possible to draw conclusions about factors that affect mode choice and traffic behaviour in various different contexts. The solutions were presented in a best practice catalogue.

DUMAS produced a framework for the design and evaluation of urban safety initiatives by bringing together the existing knowledge on the affects of safety measures with the overall planning and management of urban safety programmes. Because Urban Safety Management includes all aspects of transportation, DUMAS’ output can play a role in strategies that balance safety, mobility, and environmental issues.

The OECD report on the safety of vulnerable road users gave a very extensive overview of the mobility and safety of pedestrians and cyclists, bringing together a lot of data, and defining the most prominent safety problems. It reviewed measures and policies focusing on recent approaches in the areas of infrastructure, urban planning, regulations, education, and combinations of these, as well as on some of their effects and implementation requirements.

To compare these projects with PROMISING: PROMISING developed safety measures for vulnerable road users that are non-restrictive, so enhancing both their safety and their mobility. Pedestrians and cyclists were target groups, as were motorised two-wheelers and young drivers.

A framework for a balance between the needs of different modes and target groups was developed. On the basis of data on problems and measures, costs and benefits of a number of solutions were calculated.

2.2. Results

Safety needs

The OECD gave a survey of the state-of-the-art in safety analysis and presented it in a historical perspective. The 1960s and 1970s were marked by rapid expansion of car ownership. The accommodation of car traffic often had disastrous effects for vulnerable road users and residents of built-up areas, e.g. widening of the carriageway at the expense of road sides and pedestrian footpaths, with increased vehicle speeds as a side-effect. Urban areas expanded, increasing travel distances and thus eliminating walking and cycling as means of transport. Some new residential areas were built on the principle of complete segregation of pedestrians and motor vehicles.

The trend started to reverse at the end of the 1970s when it was found that the street networks of old towns and city centres could not cope with an unlimited increase in traffic. In residential areas, a new concept of integration of mixed traffic appeared, based on the idea that drivers would have to slow down. The Dutch 'woonerf' (homezone; residential area with restrictions to slow down traffic) and traffic calming were introduced.

Figure 2.1. *Residential area in Utrecht, the Netherlands.*

In the 1980s, the idea of a comprehensive networks for pedestrians and cyclists started to gain acceptance, together with the notion that fast motor traffic might have to give priority to local traffic and vulnerable road users. In the 1990s, long-term planning for sustainable transport policies, aimed at fulfilling mobility needs while reducing health costs, was promoted.

Against this background, the accident problems of vulnerable road users should be understood.

In ADONIS, similar conclusions were reached on the basis of a qualitative analysis by means of personal interviews with pedestrians, cyclists and car drivers who had been involved in accidents: the interaction with motor vehicles provides the most serious problems. The interviews highlight inattention, non-compliance with the rules, misjudgement, and poor visibility as factors that all are related to interaction. Increased safety of routes by means of facilities for pedestrians and cyclists, and speed-reducing measures by infrastructural means and enforcement are important solutions, combined with reduced waiting times for pedestrians and cyclists and better lighting.

The behavioural study showed that the main reason why people in Barcelona do not make use of the bicycle is safety problems. Safety is not a main factor in mode choice in Amsterdam and Copenhagen, which both have many facilities for cyclists and a large proportion of cyclists in the traffic.

WALCYNG contributed a comparison of the risk of a fatal accident per kilometre for cyclists in 10 countries. The risk of a fatal accident is 3 or 4 times higher in countries with a low usage compared to countries with the highest usage.

This underlines the fact that safety and mobility cannot be considered independently of each other. A higher share of cyclists or pedestrians and the appearance of road facilities for them, improve their safety. WALCYNG also stressed that pedestrians and cyclists do not always concentrate on other traffic, since walking and cycling, as well as fulfilling a transport purpose, are meant to be pleasant, relaxed, and social activities.

DUMAS also stressed the interdependency of safety and mobility. The main reason mentioned is that safety on its own is not a sufficiently powerful motivation to get programmes under way. Successful strategies are:
- a commitment by authorities to achieve a safety target,
- sharing the interests of different policies.

In residential areas, the ‘habitat’ function of the public space has to be of major importance. The probability of accidents should be reduced in advance by means of the infrastructural design. Safety analysis shows that accidents in towns are scattered over an area, so an area-wide approach is needed.

The framework that is most relevant is the ‘hierarchical network structure’, in which the design of the road and its place in the hierarchy corresponds to its functions of respectively:
- rapid processing of through-traffic,
- distributing traffic for rapid accessing of districts of built-up areas,
- providing for local access.

Road users should be able to recognise the function of the road enabling them to adjust their behaviour accordingly.

Mobility needs

Regarding the mobility needs, ADONIS stresses that walking and cycling have to be considered as a means of transport. An important consequence is that a network of main routes has to be created. Another is that cyclists and pedestrians must be awarded priority (right-of-way).

But the first and most important step in the direction of creating a sustainable mobility system is to take into account non-motorised road users in the planning phase of the transport and traffic system.
Speed, safety and comfort of cyclists and pedestrians should be borne in mind too. This is the starting point for consideration of possible interactions with motor traffic.

WALCYNG arrives at the same conclusion. In a literature survey, it was found that problems of pedestrians and cyclists were usually not described from their point of view.

A better social climate for walking and cycling has to be created. The advantages of walking and cycling relate to health, fun, relaxation, fresh air and the fact that they are environmentally friendly. In terms of transport and more practical aspects, the benefits include independence, flexibility and economic efficiency. Problems are related to feelings of insecurity, problems with the transport of heavy loads, and the time required, to choose for walking and cycling.

While WALCYNG found that time is an argument for not walking or cycling, ADONIS found that the main reason for cycling in Amsterdam and Copenhagen is that it is quick. This can be explained, however. With good planning, for short trips in towns, cycling will be quicker than car driving, especially when parking is taken into account. WALCYNG points out that until people have actually experienced it, they are unlikely to be aware of how fast cycling can be.

Figure 2.2. *Cycling in the inner city of Amsterdam, the Netherlands.*

The behavioural study of ADONIS, analysing determinants of mode choice, showed that habits and perceived behavioural control have a greater impact on choice than social norms and attitudes. Both projects express the need for communication and education. WALCYNG describes in more detail how the development of products that correspond to people's needs and desires should go together with incentive strategies and communication. And both projects recommend good parking facilities for bicycles, e.g. at connections with public transport.

DUMAS proposes a model in which the urban system is split into three parts: urban structure, transport networks and mobility/behaviour. The influencing factors on this system are then considered in terms of the consequences – which include qualities such as accessibility, living conditions and distribution of urban space. The disadvantages include pollution, urban hazards, congestion, feelings of insecurity, poor living conditions and public transport problems. The consequences affect management policies that cover transport, economy, land use, energy, image, environment, social and 'others'.

The OECD report presents an overview of infrastructural and non-infrastructural measures. As in the other reports, the specific demands of particularly vulnerable road users, such as children, the elderly and the disabled people are pointed out. The transport needs of these groups should be studied more carefully. Fear of getting involved in an accident and feelings of insecurity may prevent people from fulfilling their transport wishes. The construction and condition of the road or street network should be such as to make it suitable for use by them. The main principles are to remove impassable barriers and unexpected hindrances, to improve the continuity of walking routes and networks, and to provide guidance.

There are indications that children are less and less often left to make trips on their own. Elderly people often have to cope with crossing conditions and pavements that reduce their mobility. Few cities have designed specific facilities to promote mobility of the disabled.

2.3. Implementation strategies and constraints

ADONIS concludes that in many cities, even if pedestrians and cyclists account for a large amount of transport, no, or only inadequate information on the total number of trips and of their share of the city transport pattern is available. There seems to be a certain resistance to admit the real importance of non-motorised trips in the total mobility framework.

ADONIS states that if the share of cycling and walking is small and the density of facilities is low, a start has to be made with elementary measures. The best practice catalogue is a selection of measures with an innovative character. Cities in which cycling and walking account for only a small percentage of urban trips, and which have a low density of facilities for these modes of transport, may benefit more from measures in basic manuals.

The WP on vulnerable road users in DUMAS concluded that not so much is known about the effects of positive measures when these measures are applied in other situations, such as countries with less experience of traffic calming and policies for vulnerable road users.
So although the presentation of policies and good examples will be stimulating, the implementation of principles and the tuning of measures to the context are not simple.

WALCYNG adds to this the dynamics of the contextual situation: we are dealing with a societal subject in change. The attractiveness of WALCYNG facilities depends on the perspective that the users take. Such a perspective is context-related. It depends on the comfort users perceive, on values they believe in, on the experienced fairness of the preconditions that are connected to the behaviour etc. All of these variables change over time. The scientific job is thus to understand, to describe and to communicate, more than to measure and to construct. Referring to the different context for implementation of strategies and measures, WALCYNG concludes that politicians, decision-makers, officials etc. have to be included as target groups (which could not be done in the framework of their research). Cost aspects should be tackled especially thoroughly.

The OECD report presents six principles to use, that may guide the process for solutions:

1. give priority to vulnerable road users in planning the environment in built-up areas,
2. reduce vehicle speeds and promote traffic integration in built-up areas,
3. make the road ‘readable’ and the traffic environment ‘forgiving’,
4. listen to vulnerable road users before taking decisions,
5. organise demonstration projects,
6. provide homogenous design principles for the road and transport environment.

Encouragement of non-motorised transport may involve restrictions on motor vehicle traffic. For further progress to be made in road safety and particularly in safety of vulnerable road users, all road users must take part in traffic on fairly equal terms. At the macro level, this implies a complete change in the legal, physical and social environment of vulnerable road users, including a shift of transport policies towards a better balance of transport modes. It also implies more equitable allocation of road space to all groups of road users, and psychological action to prepare road users to adapt to new situations. Such changes cannot be attained at once, but only through an iterative process.

3. Mobility and safety, current situation

In this chapter, a survey of the state-of-the-art is presented for mobility and safety patterns for different modes of transport. The interrelation between mobility and safety is highlighted in connection with the aim of the PROMISING project.

First, mobility patterns between countries are compared; this comparison is followed by a summary of factors that influence mobility. Second, a comparison of safety levels between countries is presented along with main factors related to these. After this, additional data per target group are presented.

3.1. Comparing mobility

In the EU as a whole there are 2 inhabitants per motor vehicle. In Greece and Ireland there are about 3 inhabitants per motor vehicle (FERSI, 1996). About half of the motorised two-wheelers are in use in Southern Europe: Portugal, Spain and Italy. The share of bicycle trips in Europe varies from about zero in some countries to 28% in the Netherlands. The share of walking trips varies from 15 to 30%, the highest share being in the UK.

In *Tables 3.1 and 3.2*, the distances and in trips per person per day for three countries are presented as an illustration of the variety of transport behaviour in Europe, even if we only consider North-Western Europe.

	Great Britain (1985-86)	Sweden (1984-85)	The Netherlands (1986)
Car driver	10.6	193	15.4
Car passenger	7	82	84
Public transport	3.7	81	4.1
Pedal cycle	0.2	8	31
Pedestrian	1.1	8	0.9
Other	0.9	3	1.3
All	23.5	375	33.2

N.B. The Swedish data is only for persons aged 15-84 and the Netherlands data excludes travel by persons aged less than 12.

Table 3.1. *Distance (km) per person per day by main modes of transport (Tight & Carsten, 1989).*

	Great Britain (1985-86)	Sweden (1984-85)	The Netherlands (1986)
Car driver	0.87	114	113
Car passenger	0.54	42	48
Public transport	0.31	34	18
Pedal cycle	0.07	32	95
Pedestrian	0.95	66	6
Other	0.05	4	9
All	2.8	292	343

N.B. The Swedish data is only for persons aged 15-84 and the Netherlands data excludes travel by persons aged less than 12.

Table 3.2. *Trips per person per day by main modes of travel (Tight & Carsten, 1989).*

The Swedes travel 1.6 times as far as the British and about the same as the Dutch. However, walking and cycling make up 5 and 4 percent of the total distance travelled in Britain and Sweden respectively and 12 percent in the Netherlands. When not in their cars, the Swedes use public transport and the Dutch cycle. On average the British do not travel as far as the Swedes or the Dutch: when not travelling by car they are most likely to be on public transport or walking.

3.2. Factors influencing mobility

It is generally agreed that mobility is economically driven. Car ownership is the main variable explaining the choice of transport mode.

The choice of walking and cycling as a means of transport probably depends on a large number of factors. In particular, a traffic and physical environment which is not user-friendly and strong feelings of being unsafe may act as deterrents, although this phenomenon has not been quantified. This relation is especially pronounced for the more vulnerable pedestrians: if, as observed for example in Great Britain, children walk less and less and are more often ferried by a parent by car, it is no doubt for fear of accidents, perhaps for fear of other dangers. It is concluded from a survey in four residential areas in the Netherlands that in places where basic traffic engineering measures have been taken, the children enjoy a greater freedom of movement but that even those children living in a 'woonerf' (homezone) have their movements restricted by the nearest busy road. Elderly people tend to avoid walking trips which are not absolutely necessary when the walking conditions are difficult or uncomfortable, or when danger from complex traffic situations is strongly felt: there is a trade-off between safety and mobility. A one-day survey showed that 50% of disabled people walked, compared to 75% for the population as a whole (PROMISING, 2001a).

Concerning cycling, the situation varies considerably in Europe. While in some cities, such as Madrid, the level of bicycle use is extremely low, in others, such as Groningen in the Netherlands, about 57% of all trips are made by bicycle. In France and Great Britain, bicycle ownership is high but the usage is rather low. Very different policies exist at city, region and country level, and the systems of government and their respective powers will also have an impact on bicycle use. Cultural backgrounds and the legal and fiscal situation also have an impact. Climate and terrain do have an impact, but a smaller one than might be estimated. E.g. Finland is not known for having a mild climate, yet in Oulu, a city with a population of over 100,000, 35% of all trips are made by bicycle. Oulu is just over 100 miles south of the Arctic circle. In Padua and Ferrara in the Po valley of Italy, bicycle usage is also at this level, but the climate is hot there for many months of the year, and cold and damp in the winter. Basel in Switzerland is scarcely flat, but has 17% bicycle use and only 27% car use. Climate and terrain obviously are factors that determine the level of bicycle use, but their importance is sometimes overemphasised (PROMISING, 2001b).

Figure 3.1. *Helsinki, Finland.*

Figure 3.2. *Special gloves for cycling in winter time, Utrecht, the Netherlands.*

The usage of motorised two-wheelers is steadily increasing. Between 1980 and 1990, the total number of motorised two-wheelers in use first fell, then rose and continued to do so in the nineties. The fall was due to a fall in the number of mopeds. During the 1950s, motorised two-wheelers were used predominantly for functional purposes. With increasing availability of cars, however, the emphasis shifted more to leisure time use. In the last ten years, because of the problems of urban traffic, motorised two-wheelers are being used increasingly for functional purposes in addition to leisure purposes. The proportion of motorised two-wheelers in transport in Western Europe is about 3%, or half of the transport volume by public transport (PROMISING, 2001c).

3.3. **Comparisons of risk**

The vulnerability of four groups of road users formed the basis for the PROMISING project. Comparison of the number of accident victims per kilometre for the four categories of vulnerable road users shows very large differences (see also *Figure 3.3*).

Figure 3.3. *Risk of fatal injuries per kilometre travelled in the Netherlands for different modes of transport and some age groups in 1995 - 1997.*

Figure 3.3 shows that he risk for persons riding motorised two-wheelers is much higher than for those using other modes. Young people are more at risk than people aged 40 - 50 years when they drive or ride a motor vehicle. Elderly people have a much higher risk of fatal injuries, especially as pedestrians, cyclists or riders of motorised two-wheelers, when their bodies are not protected.

The data presented here for comparison of risk does not give a picture of the risk per trip. This data is not available. Comparisons on the basis of travel kilometres are not fair, because the kilometres of different modes are made on different road types with different safety facilities.

The differences of risk are influenced by different exposure conditions:

- More than one third of all car kilometres are driven on highways that have been made very safe. If only those roads are considered which are also used by cyclists and pedestrians, the risk for car driving compared to walking and cycling will be higher.
- Young drivers have a higher share of trips during weekend nights. Their risk in the daytime only is much lower.
- Other road users tend to avoid situations when the risk of accidents is greatest. Motorcyclists ride more in good weather. Elderly people tend to avoid road use during peak hours and at night.
- The fatality rate for cyclists is known to vary in inverse proportion to the amount of cycling per occupant. In countries where people cycle a lot, cyclists have a lower fatality rate. Also the risk for pedestrians and cyclist at crossings decreases with increasing numbers of pedestrians and cyclists.

An estimation in the Netherlands, comparing the risk for different modes of transport for the same trip, shows e.g. that cycling is safer than car driving for people up to about 40 years of age. Cycling is safer up to an age of about 50 years if we also take into account the risk of injury to other road users (EC DGXI, 1999).

A calculation performed in the United Kingdom, using data from 1988, shows how the differences in casualty rates vary with the choice of exposure unit: trips, kilometres, or hours (see *Table 3.3*).

Table 3.3 shows that, based on the figures for killed and seriously injured in terms of distance, walking is about 12 times more dangerous than car travel. But in terms of time spent travelling, the risks are more similar, with walking being one and a half times more dangerous than being in a car, and in terms of number of trips, there is about the same risk during a walking trip as during a car trip.

	Casualties	Casualty rate per 100 million		
		Trips	Kilometres	Hours
Killed				
Pedal cycle	227	12.5	4.6	64
Walking	1753	7	6.6	27
Motorcycle	670	122	11.4	342
Car	2142	5.2	0.4	12.4
Bus and Coach	17	0.4	0.06	1.4
Killed and Seriously Injured (KSI)				
Pedal cycle	4879	268	98	1377
Walking	17880	72	68	279
Motorcycle	12654	2311	215	6461
Car	29346	71	5.7	170
Bus and coach	892	14	2	51

From: Transport Statistics Great Britain 1979-1989

Table 3.3. *Number of casualties per units travelled by occupants and riders of several transport modes in the year 1988 (from PROMISING, 2001e).*

3.4. Factors of influence for high risk

Protection
The vulnerability of the body plays an important role to explain the risk differences between the different modes. Car occupants are protected to a certain extent by the bodywork of their vehicles. The damage caused by a collision is a consequence of momentum (mass and speed). Motor vehicles cause serious injuries to pedestrians and cyclists, but it is very unusual for occupants of motor vehicles to be killed by a pedestrian or cyclist. In simple terms, the mass and speed of motor vehicles is in general not compatible with non-motorised transport. For motorised two-wheelers, the absence of a bodywork means also that the riders have little or no protection against collision impact.

Vehicle characteristics
One reason for the high risk of motorised two-wheelers is that they are single-track vehicles. The rider has difficulty controlling the vehicle, in

particular when cornering or braking, and even more so in emergency situations. It also means that the rider has more difficulty coping with imperfect road surfaces and obstacles on the road. A small frontal area contributes to the problem of the perception of mopeds/motorcycles by other road users. Small numbers of mopeds/motorcycles on the road also contribute to this problem. The small size of a moped/motorcycle and its low weight in relation to its engine performance enable the rider to behave in a manner different from that of car drivers. Motorised two-wheelers can overtake where cars cannot: they can accelerate faster.

Priority in planning and design

The greater safety problems of two-wheelers and pedestrians may also be influenced by the priority in planning for cars. Planners and designers are much more aware of the needs for comfort and efficiency of car drivers than of the needs of two-wheeler riders and pedestrians. This is also reflected in the efforts for the maintenance of facilities. One of the consequences is non-compliance with rules such as walking or cycling through red traffic lights.

Figure 3.4. *Wrong design for pedestrians and cyclists, Utrecht, the Netherlands*

Figure 3.5. *Too small space for pedestrians and cyclists, Helsinki, Finland.*

Relation to exposure

When fewer people choose to walk or cycle, planning for them is given less priority and problems are not resolved. Moreover, differences in exposition lead to differences in the risk per travel kilometre. A low proportion of a mode in traffic affects expectations and results in worse anticipation by other road users. The differences in risk for cyclists between countries with a high usage and those with a low usage confirm this. Also motorised two-wheelers often “appear out of nowhere”.

Lack of communication

Lack of communication between road users is a basic element of accident-generating processes, as drivers may be surprised by unexpected actions or may misunderstand each other’s intentions. Communication is made difficult when speeds are high but also when the physical environment is not designed to help drivers focus their attention on pedestrians, or when there are visibility problems. Differences in expectations between road users also play an important part; if different road users interpret local rules or requirements in different ways or get different messages from what they see of the road, conflicts are inevitable. Differences in expectations may be generated by unclear road design as well as by visibility problems. They may also result from the driver's lack of attention to pedestrians and failure to be aware of the risk to the vulnerable party should a collision occur.

Age
Elderly people run a much higher risk of being killed or seriously injured in accidents because of the vulnerability of their bodies. Children and youngsters have a much higher risk of being involved in accidents because of their lack of skills and their inexperience. Moreover, young people have a lifestyle which exposes them to critical traffic situations: they frequently drive at night, in the weekend and in the company of friends, and after disco and pub visits. Young people also have to cope with a variety of developmental problems: they want to become independent of their parents and want to develop their own identities. Showing-off with driving in front of their peer group may raise self-esteem.

Risk-seeking
Sensation-seeking applies to about 30% of the car-driving population. Young drivers tend to be less concerned with their own speed as a potential risk factor. In combination with a lower seat belt use, they put themselves more at risk. Most riders of motorised two-wheelers enjoy the direct sensation of speed (offered by the absence of a bodywork) and the control of the vehicle with the whole body. Other riders are more attracted to use a moped/motorcycle because of the opportunities to overtake, to accelerate and go fast.

The next four sections provides more detailed information concerning the mobility and safety of the four categories of vulnerable road users.

3.5. Pedestrians

3.5.1. *Mobility*

Walking as a mean of transport is commonly used for rather short trips. This means that it is actually difficult to assess pedestrian mobility at country level, as the national travel surveys often do not register the shorter trips. Also, the walking parts of trips made primarily by public transport are usually not taken into account. At present, the importance of walking is therefore underestimated.

Survey data from a selection of seven European countries show that 15-30% of all trips are made by walking, the highest figure being for Great Britain. The proportion decreases significantly if only trips between home and work are considered. For short trips under 5 km, the share of walking may rise to 40%.

The average length of walking trips varies from just under 1 km to 2.8 km. The larger the city, the more walking trips people tend to perform. Generally, the number of daily walking trips is higher for women than for men. Overall, the distances and the proportions of trips performed by walking seem to have been decreasing since the early 1980s, which may be partly related both to the increased travelling distances resulting from urban development, and to the increase of vehicle ownership.

3.5.2. *Safety*

Pedestrians form the second largest group of road casualties (after car occupants). They account for about 15% of the road fatalities in the European Union. The over-55 and under-12 age groups are those with the highest risk of pedestrian casualties.

Compared with most other road accident types, the severity of pedestrian accidents is high due to the vulnerability of pedestrians vis-à-vis the vehicles. Pedestrians have the highest ratio of deaths to injuries of all categories of people injured by motor vehicles: it is about twice as high as that for motorcyclists, and over four times higher than that for motor vehicle occupants.

In most countries, accidents involving pedestrians (apart from those resulting in fatal injuries) tend to be underreported. Statistics can thus be considered to provide an optimistic view of the pedestrian safety problem.

Moreover, pedestrians' own perception of 'safety', in particular in the case of women and elderly pedestrians, also includes considerations of safety from violence or robbery, especially during hours of darkness.

3.6. **Cyclists**

3.6.1. *Mobility*

The Dutch have the largest figure for bicycle use per inhabitant in Europe: on average more than 1,000 bicycle kilometres per inhabitant per year and a modal share of 28%. With 16 million people, they own 16 million bicycles and make, on average, 16 million bicycle trips per day. Denmark follows with 960 bicycle kilometres per inhabitant per year and a share of 18%.

The average of kilometres/year/person in the EU is 200. Austria, Belgium, Finland, Germany, Ireland, Italy and Sweden are in the range between 100 and 400; France, Greece, Luxembourg, Portugal, Spain and the United Kingdom are in the range below 100. However, there are strong regional differences in countries where cycling is not very common; also in those countries, cycling accounts, in some cities, for one third of all trips. Cycle use seems, on the whole, to have been stable in the recent past.

Bicycle ownership is not closely linked to bicycle use. An increase in the numbers of bicycles in France and the United Kingdom did not lead to an increase in bicycle use.

There is a huge potential for growth of bicycle use. Replacement of only a quarter of short car trips with bicycle trips would double the bicycle modal share in countries such as Finland and Norway, and increase it by a factor of 3 in the United Kingdom and by a factor of 4 in France.

In countries where cycling as a mode of transport is not very common, statistics are not easily available.

3.6.2. *Safety*

The number of cyclists killed per cycled kilometre is very much influenced by the total number of cycled kilometres. The accident risk based on the amount of cycling is lowest in Denmark and the Netherlands (15.9 and 17.6 fatalities per billion km, respectively). The risk is particularly high in France and Great Britain (67.7 and 52.5, respectively), where the amount of cycling is low.

It has been proven that the risk decreases as exposure increases. An increase in cycling is not automatically linked with a linear increase in road casualties.

As in the case of pedestrians, non-fatal injuries to cyclists are very much underreported. To ask for more priority to their safety needs, a good registration of their problems is of course necessary. Also their fear of accidents and other dangers play a role in their mobility choice.

Six hospital-based underreporting studies carried out in Great Britain have been summarised in *Table 3.4*, which gives the ranges of levels of underreporting for different degrees of injury severity and for different road users.

Road user	Seriousness of injury	Percentage reported		
		Minimum	Maximum	Average
Vehicle occupant	Fatal	100	100	100
	Serious	85	91	89
	Slight	70	82	77
	All injuries	75	86	81
Pedestrian	Fatal	100	100	100
	Serious	82	91	85
	Slight	60	80	67
	All injuries	73	85	77
Motorcyclist	Fatal	100	100	100
	Serious	67	73	70
	Slight	42	63	51
	All injuries	56	66	61
Pedal cyclist	Fatal	100	100	100
	Serious	17	41	33
	Slight	9	29	21
	All injuries	22	34	27

Table 3.4. *Percentages of casualties reported. The figures are estimated from six hospital-based studies in Great Britain (from PROMISING, 2001e).*

3.7. **Motorised two-wheelers**

3.7.1. *Mobility*

In the EU there are about 13 million mopeds. This number has not changed much over the past ten years. The number of motorcycles is lower than the number of mopeds, at almost 10 million. This number is slowly but surely increasing.

There is a clear regional pattern, with many more mopeds/motorcycles in Southern European countries than in Northern Europe. In Southern Europe, there are approx. 50 mopeds and 30-40 motorcycles per 1,000 inhabitants. In northern countries the figures are approx. 20 for mopeds and 10 for motorcycles.

Because of the low minimum age for moped riding, many of the riders are young. In recent years scooter models have become popular. Motorcycle riders used to be young as well, but there is a long-term trend with fewer young riders and many more older riders. Today about 75% of motorcyclists are more than 25 years old. The proportion of female riders of mopeds and motorcycles is small and seems to vary from country to country.

For some countries in Central and Western Europe, the average number of kilometres per year is estimated at 2,000-3,000 per moped and 5,000-6,000 per motorcycle. Motorcycles are mostly used for recreational trips, but the proportion of riders who use their motorcycles daily is nevertheless close to 50%. Daily use is probably higher for mopeds than for motorcycles.

Other factors that are likely to influence the number and use of mopeds/ motorcycles are the direct costs involved, legislation, and the range of models on the market. Ownership and use of a moped/motorcycle also has a strong emotional value.

3.7.2. *Safety*

Motorcycle and moped fatalities in Western Europe together represent 10-15% of all traffic fatalities. These numbers are high in relation to the numbers of vehicles. The number of fatalities per 10^5 vehicles is higher for motorcycles. However, the use of motorcycles in terms of kilometrage is probably higher.

Several factors contribute to the large differences between the fatality rates of mopeds and motorcycles for different countries. The characteristics of the rider population may be different. As a consequence of differences in legislation, the age distribution and level of training will vary. The conditions of riding in terms of type of road, other traffic etc. may also differ between countries. The extent to which these factors actually contribute in different countries is not known, however.

For both mopeds and motorcycles, the rate of fatalities per 10^5 vehicles is much higher for younger riders than for older riders. The percentage change in fatality rates per 100,000 vehicles shows a positive trend between 1990 and 1995. Only Ireland and Greece exhibited increasing fatality rates in these five years. All other countries had fatality rate decreases of between 20 % and 55%.

3.8. Young drivers

3.8.1. *Mobility*

Young people frequently drive at night, at the weekend, and in the company of friends. As a solution to the road safety problems resulting from this exposure to the most dangerous circumstances, alternatives such as public transport services to discotheques have been developed in some countries. The acceptance of these alternatives depends strongly on their image and their convenience. A free public transport pass for students introduced in the Netherlands resulted in lower car use.

3.8.2. *Safety*

It can be seen that in almost all European countries road accidents are the major cause of death among young people. In all countries, their safety situation is influenced also by the general safety situation. It is to be seen, however, that the positive trend in overall mortality rates in Europe does not apply to people aged 18 - 20 years. Per 100,000 inhabitants, 3 times as many people aged 18 - 20, and twice as many aged 21 - 24 die in cars as people aged 25 - 65. During the past years, there has been a decrease in the mortality of car drivers; this does not, however, apply for the youngest group below 21.

Weekend night-time trips are particularly dangerous. In Germany, for example, 40% of all fatalities among 18 - 24-year-old car drivers and passengers occur during leisure-related trips during a 12-hour period during the weekend. Driving under the influence of alcohol is a major cause of night-time leisure-related accidents.

It is important also to look at the contribution to (fatal) injuries to others. Car driving poses a major threat to other road users.

Young riders and drivers are more often to blame than older riders and drivers for errors that cause accidents . In the age group under 25 years, motorcyclists are less often to blame for accidents than car drivers. Young car drivers more frequently commit errors relating to ‘giving right-of-way’, ‘keeping distance’ and ‘turning in’ than motorcyclists in the same age group. Only for ‘faults when overtaking’ do the motorcyclists figure more highly. Also alcohol was found much more frequently among the car drivers.

4. Legislation

Without presenting an overview of current legislation in Europe, it is important to highlight some characteristics and to point at differences in Europe so that the context of mobility and safety patterns can be better understood. The data in this chapter concerning walking and cycling refer to the OECD report on vulnerable road users (1997) and a report by BASt (1997).

Regarding walking, cycling, and moped/motorcycle riding, it is important to look at legal guidelines, traffic regulations and design standards for infrastructural facilities. Regarding young drivers and riders, it is important also to look at age and vehicle use limitations.

In the framework of the PROMISING project, it is also important to look at the legal balance between different modes of transport. In general, vulnerable road users have to be protected: The ‘Treaty of Vienna’ of 1993 states: “Drivers should be particularly careful with respect to the weakest road users such as pedestrians and cyclists, particularly with respect to children, the elderly and the disabled.”

But the PROMISING working group on pedestrians concludes that enforcement of pedestrian rights is not always adequate, as police strategies generally focus on more general laws (speeding, drinking-and-driving, etc.). Laws protecting pedestrians are unevenly integrated in police work as in engineering practice.

In the next sections, some of the most important traffic rules for the different target groups are described.

4.1. Pedestrians

The most common description of a pedestrian is a person who travels by foot or pushes a vehicle. In general, skeelers and skaters also belong to the ‘pedestrian’ category.

Upon examining traffic rules and laws in Europe concerning pedestrians, the pedestrian report (PROMISING, 2001a) concluded that, in the 1960s and 1970s, the primary aim of traffic rules was the orderly movement of motor traffic; pedestrians have thus been regarded as external to the traffic system, needing protection, but also disturbing traffic and therefore needing to be restrained in their movements. Recently, more emphasis has been put on pedestrian rights, at least in urban areas. The present regulatory environment shows compromises, that vary from country to country, between these two approaches.

The place reserved for walking on public roads is the pavements, footpaths and verges or, when this is not possible, cycle tracks if they exist, otherwise the roadside and in that case as close as possible to the edge of the roadside and in single file. Some countries have regulations or recommendations on the minimum width of pavements, but these do not always take into account the space requirements of disabled people.

In most countries pedestrians should cross carriageways on pedestrian crossings if there is one available near by, taking due care to other traffic. The obligations to drivers at those crossings are becoming stronger, to adjust speed and to stop to allow pedestrians to pass.

4.2. **Cyclists**

A bicycle is a vehicle with at least two-wheels, that is propelled solely by the muscular energy of the person riding it. According to the Vienna Convention, a bicycle should be equipped with brakes, a bell, a red reflecting device at the rear, devices ensuring that the bicycle can show white or yellow lights at the front and red lights at the rear. It is important therefore that every bicycle on sale meets all the requirements. Moreover, the devices should be reliable and easily maintainable. This makes the requirements less restrictive, because if the devices do not work properly and have to be repaired, the bicycle will be used less.

As a rule, cyclists must keep to cycle tracks where they exist, but in some countries they are allowed to ride on the road if this is more suitable. This is a motive for designers to provide facilities of a good standard. The new regulations in Germany concerning cyclists include contraflow cycling in selected one-way streets and a code for bicycle streets where cyclists may make use of the whole street and cars have to stay behind. The changes also include shared use of bus lanes, cycle lanes on roads and various marking solutions for junctions.

The rules concerning riding abreast differ: in some countries it is not allowed, in other countries it is allowed provided it does not cause danger or impediment. Design manuals for bicycle facilities generally make it possible to ride abreast. In general drivers are obliged to keep a sufficient distance from cyclists when they overtake.

The question whether a regulation is adequate or not has been formally raised, for example in the Netherlands where the recently revised Dutch Highway Code (the ‘RVV 1990') points out that “in a great number of situations, road users are very well capable of determining for themselves which behaviour is desired and safe”, which reduces behavioural specifications and therefore the restrictiveness of the law for all road users.

The rules concerning right-of-way for motor vehicles mostly apply for cyclists too. In urban areas, for safety and mobility reasons, more and more solutions are being found to ensure priority for cyclists - and pedestrians - at crossings. Possibilities are:

- leading phase for cyclists and pedestrians,
- traffic lights that provide a green phase to cyclists and pedestrians twice during each cycle,
- detectors that provide cyclists and pedestrians with green light as soon as they arrive at a crossing,
- advanced stopping lines at crossings with traffic lights, to enable cyclists to wait in front of motor traffic and to continue first (see *Figure 4.1*),
- providing cyclists with the right to turn right when motor traffic has to wait for a red light.

Figure 4.1. *Advanced stopping line in Paris, France.*

4.3. Motorised two-wheelers

As a result of European regulations, the legislation concerning mopeds and motorcycles has become more uniform in recent years. But there are still many differences in detail.

In most European countries, mopeds now have a maximum speed of 45 km/h and an engine capacity of less than 50 cc. The minimum age for riding a moped varies between 14 and 18 years. Some countries have special sub-categories of mopeds with lower speed limits.

Many countries, but not all, require a special test to be passed. This is usually a theoretical and practical test, but some countries have only a theoretical test. Several countries allow riding of a moped at a lower age after a test has been passed, resp. at a higher age without a test or with a car or motorcycle licence instead of a special test. Countries with low-speed mopeds usually have a lower age limit for riding these mopeds and/or a simpler test or no test at all.

Some countries allow riders of (slow) mopeds to use bicycle facilities; some countries do not allow passengers on mopeds; in some countries the wearing of a helmet is not compulsory for all moped riders.

The European regulations require a minimum age of 18 for riding of a motorcycle with limited engine performance and a theoretical and practical test. Great Britain makes an exception with an age limit of 17 years. Riding of an unlimited motorcycle is allowed after at least two years of riding a limited motorcycle. The European regulations also provide the option of an age limit of 21 for unlimited motorcycles (and a theoretical and practical test) without prior experience on a limited one. Most European countries have now adopted this option.

A special category of lightweight motorcycles with an engine capacity of less than 125 cc and limited performance is recognised by the European regulations. The minimum age for this category is 16 years and there is an option allowing the use with a car licence instead of a special theoretical and practical test. Not all countries have adopted the 125 cc category and of those which have, some have a higher age limit than 16 and some have chosen the option of a car licence replacing a special test. Some countries have special restrictions for beginner riders such as a ban on passengers or on motorway riding.

With regard to riding speed and position on the road, motorcyclists follow the same traffic rules as car drivers. Some European countries require the use of headlamps during daytime by all motor vehicles (including mopeds/ motorcycles) and some have this requirement only for mopeds/motorcycles. Helmets are compulsory for motorcyclists in all countries, although actual wearing rates may be lower than 100%.

4.4. Young drivers

In almost all European countries, the minimum age for driving is 18 years. Exceptions are the United Kingdom and Poland, where the minimum age for obtaining a licence is 17. France and Sweden are exceptions in the sense that accompanied driving, under the supervision of a parent or friend, is allowed for young people of 16 years or older. The minimum age for actually obtaining the driving licence in France is also 18 years.

Differences in legislation between European countries concerning road user behaviour are in general the same for young drivers, but there are exceptions. The limit for blood alcohol concentration (the BAC limit) for drivers is 0.5‰ or 0.8‰ but in Austria, which has a general limit of 0.8‰, the limit for young drivers is 0.2‰.

4.5. New guidelines and highway codes

In Italy new guidelines have been introduced that better meet the needs of pedestrians and cyclists. The new Urban Traffic Plan law calls for ‘environmental islands’ (i.e. places with homogeneous features) in urban areas, characterised by continuity of the pedestrian network and allowing the improvement of the pedestrians’ situation in urban traffic - through car speed limits, reduction of car traffic, and provision of larger and properly dimensioned and equipped spaces for pedestrians. Moreover, the latest legislation in Italy includes minimum width standards for footways and for new sidewalks, to accommodate wheelchair users, as well as provisions for other categories of disabled people and for the continuity of pedestrian paths in the urban context.

Another new Italian law on ‘Rules for financing bicycle mobility’ makes it the responsibility of the various regions to draw up plans for cycling facilities, to publish cycle maps and to provide education in schools on sustainable transport.

In the 1990s several countries produced manuals for the design of facilities for cyclists (see *Figure 4.2*). These manuals serve as guidelines or strong recommendations for planners.

Figure 4.2. *"Sign up/design for the bike". Design manual for bicycle facilities, the Netherlands.*

Germany recently amended the traffic code for cyclists. Some new elements have already been mentioned, such as contraflow cycling in selected one-way streets and a code for bicycle streets. In addition, the changes include shared use of bus lanes, cycle lanes on roads, and various marking solutions for junctions. As in some Scandinavian countries, cycle tracks can be made compulsory only if they meet appropriate minimum quality standard, otherwise cyclists may choose not to use cycle tracks. Moreover, many existing tracks will be given up because they are too dangerous or uncomfortable.

5. Measures for enhancement of safety and mobility

This chapter first presents new approaches for safety and mobility in Europe. Then summaries are given of the proposals for the four target groups of road users.

5.1. Prevention of road safety problems

New policies and strategies for road safety have been developed in e.g. the Netherlands and Sweden: the “Sustainable traffic safety concept” and the “Vision zero” approach.

The starting point of the “Sustainable safety concept” in the Netherlands is that man is basically the reference standard. According to the concept, we should try drastically to reduce the probability of accidents in advance, by means of the infrastructural design. And where accidents do occur, the process which determines the severity of these accidents should be influenced such that the possibility of serious injury is virtually eliminated.

Thus, a sustainably safe traffic system has:
- a structure that is adapted to the limitations of human capacity through proper design, and in which streets and roads have a neatly appointed function, as a result of which improper use is prevented,
- vehicles fitted with ways to simplify the driver’s tasks and constructed to protect the vulnerable human being as effectively as possible, and
- a road user who is adequately educated, informed and, where necessary, guided and restricted.

The concept can be 'translated' into some, more practically oriented, safety principles:
- prevent unintended use, i.e. use that is inappropriate to the function of that road or street,
- prevent large discrepancies in speed, direction and mass at moderate and high speeds, i.e. reduce the possibility of serious conflicts in advance,
- prevent uncertainty amongst road users, i.e. enhance the predictability of the course of the road or street and people's behaviour on the road or street.

It is estimated that, with the new policy, within about 30 years, the number of fatal accidents will be reduced by 60 to 80%. Is has been calculated that a continuation of present policies does not have this potential. To finance the change, use can be made of the yearly investments for reconstructions.

The “Vision zero” of Swedish origin has much in common with the sustainable safety concept. The starting point of its safety strategy is that the system should be dimensioned in such a way that possible conflicts, or incidents which might cause injury, never cause a politically pre-defined level of an unacceptable loss of health to be exceeded. In achieving the 'zero vision' in reality, the intention is to create a situation in which exposure to violence is minimised. At the same time, the degree of violence has to be kept below the violence tolerance level of an optimally protected human being. So, in this approach too, man is in principle the reference standard

These strategies are important frameworks for the development of measures.

Both concepts set targets for road safety in the future. Target setting has been in use for many years by different European countries. It has many advantages, such as directing policies, organisations and experts towards concrete aims. Target setting as part of policy development is effective: counties in Norway that set ambitious quantified road safety targets were more successful in bringing down accident rates than counties opting for less ambitious targets or purely qualitative targets (Elvik, 1993).

5.2. New transport policies

Also new strategies for mobility have been introduced in several European countries.

The UK government has introduced several new transport policies aimed at encouraging the use of methods of transport other than the car.
In 1998 it published its White Paper - *A New Deal for Transport: better for everyone* detailing its commitment to an Integrated Transport Policy. The paper states that planning guidance to local councils will be revised to reduce reliance on the car. Local services should be within walking distance and public transport links should be convenient. Guidance to local authorities will make it clear that higher priority should be given to walking, cycling and public transport, improved facilities for changing between these modes, and better information for passengers. Local transport plans will set local targets for increasing walking and cycling, which will be achieved by such things as giving priority at junctions to reduce waiting times, maintaining cycle lanes and footpaths properly, and reallocating road space to cyclists and pedestrians where appropriate.

Target setting is also a tool in transport policies.

In 1996 the UK government launched the National Cycling Strategy with the aim that bicycle use in the UK will double by 2002 and then double again by the year 2012. This target is to be achieved by bicycle-friendly planning, improved cyclist safety, more bicycle parking and road space, reduced bicycle theft and changing attitudes towards cycling. As well as a national target, local authorities and other transport providers and trip generators are to set local targets as part of the strategy, which will contribute to achievement of the central targets to increase bicycle use. Initiatives such as school travel plans, which establish safer routes for children to walk and cycle to school, are encouraged as part of the strategy.

Denmark’s national target is to increase the bicycle’s share of trips in urban areas by 4% by 2005. This is to be backed up by traffic funds. Finland has a target of doubling bicycle use from 1993 to 2005 and halving accidents from 1993 to 2000; considerable socio-economic savings are also expected.

The Dutch Masterplan Bike showed that national targets and a national strategy for cycling can have a significant influence on local policies. An evaluation study involving 19 local authorities showed that the intensity of planning for the bicycle has increased in connection with measures taken for the needs of bicycle use (known as pull measures) and by restricting car use (known as push measures). While small authorities (up to 50,000 inhabitants) are now more active than before with regard to bicycle traffic needs, medium sized authorities (up to 135,000 inhabitants) and large authorities are trying hard to restrict car use in combination with measures for cyclists (Dutch Ministry of Transport, 1998).

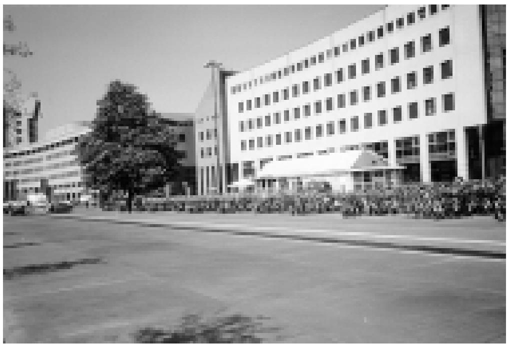

Figure 5.1. *Cycling as a feeder to train transport, Amersfoort, the Netherlands*.

5.3. **Pedestrians**

5.3.1. *A comprehensive approach*

Of the pedestrian safety actions considered in this report, the following two can be selected as being the most comprehensive and most closely associated with urban planning and policy philosophies:

- area-wide speed reduction or traffic calming schemes,
- provision of an integrated walking network.

Both of these actions apply to urban areas, where the majority of pedestrian accidents occur. However, area-wide schemes are usually applied only to residential areas; this is due to the fact that hazardous conditions are most directly felt in one’s own neighbourhood, which motivates actions to improve safety (as well as other quality-of-life aspects). On the other hand, integrated walking networks are most commonly focused on town centres, typically applied as parts of schemes to improve the quality of service for pedestrians using the city centre (as employees, shoppers, visitors etc.).

The two actions are complementary: they can be used simultaneously, without conflict. Besides applying to different parts of the urban fabric, they also address different objectives: area-wide schemes (the most widespread of which is the 30 km/h zone) are aimed at reducing vehicle speeds, thus enabling the safer mingling of pedestrians with motor traffic; while integrated walking networks (usually centred around a downtown pedestrian zone) serve to remove/reduce pedestrian-vehicle conflicts and to provide/ improve crossing points.

Figure 5.2. *"The kindest street in town". Traffic calming measures in Graz, Austria.*

Figure 5.3. *Graz, Austria.*

Figure 5.4. *Pedestrian crossing in Zwijndrecht, the Netherlands.*

A common theme of both actions is their contribution to the achievement of a more readable traffic environment. Indeed, they are both commonly proposed in current traffic planning and engineering practice as part of packages for urban areas - in conjunction with proposals for ensuring a "functionally hierarchical network" of town streets. The actions can be seen as backbones of a balanced and comprehensive approach for improving pedestrian safety.

5.3.2. *Supportive measures*

In addition to road and traffic planning and management, there are of course other requirements related to the behaviour of vehicle users: acceptance of pedestrians as road users equal to themselves, knowledge of rules and regulations protecting pedestrians, observance of pedestrian rights. To some extent, adequate road and traffic management that reflects these requirements contributes to achievement of the behaviour expected from drivers. Conversely, extensive planning for pedestrian movements is hampered by pressure exerted against such planning by other road users, and local facilities will not achieve the desired level of safety if drivers do not comply with the rules. Other measures (education, information, enforcement) are thus usually needed if the right balance is to be achieved, and additional incentives may be found in areas other than mobility and safety (environmental preoccupation, for example). Policy implementation should focus on conflict management and balancing-out of different interests.

5.3.3. *Design demands*

The demands made on the design of roads and their environment and on traffic planning and management by pedestrians' movement patterns are summarised in *Table 5.1*.

Table 5.1. *Pedestrian mobility needs (PROMISING, 2001a).*

Activities performed on the pedestrian network	Needs common to all pedestrians	Special needs of the more vulnerable pedestrians
Preparation of trips	**Planning** · Information on weather conditions, shopping times, roadworks · Precautionary measures	**Planning** · Information on existence or absence of relevant facilities
Performing trips	**Planning** · Appropriate walking network enabling pedestrians to reach all their destinations. · Shortest possible routes between two destinations, except in areas mainly devoted to leisure, commercial or cultural activities. · Possible choice between alternative routes for trips with different purposes (leisure and work trips for example).	**Planning** · Avoidance of steep gradients that may not be usable by elderly or disabled pedestrians.
Walking	**Planning** · Continuity of routes (avoiding abrupt changes in the way they are planned and the amount of attention required from the pedestrians). · Adequate location of crossings (zebras, traffic light crossings, underpasses or bridges) in order to satisfy the two requirements: shortest route, continuity. · Reduction of friction between motor or bicycle traffic and pedestrians wherever possible (segregated or separated pedestrian routes, or speed reduction). · Shelters from bad weather or for waiting	**Planning** · Rest areas (places to sit) along the walking network to enable elderly or disabled pedestrians to walk longer distances.
	Design · Adequate capacity of pedestrian walking facilities in relation to pedestrian flows. · Smooth and non-slippery surfacing for comfortable walking. · Elimination of all obstacles likely to obstruct pedestrian routes. · Specific direction signing for pedestrians, particularly on the links of the network segregated from motor traffic. · Reduction of vehicle speed on links of the network with mixed traffic (residential, commercial or historical streets). · Adequate lighting.	**Design** · Adequate width to accommodate wheelchairs · Avoidance of steep gradients and steps · Tactile guidance for blind pedestrians. · Severe reduction of vehicle speed on links where children are likely to run onto the road (around schools, sports grounds...)
	Maintenance · Clearance of snow, ice or dead leaves from pedestrian walking facilities as soon as needed. · Repair of holes and otherwise damaged surfacing as soon as needed.	

Activities performed on the pedestrian network	Needs common to all pedestrians	Special needs of the more vulnerable pedestrians
Crossing	**Planning** · Adequate location of crossings (see above) · Adequate time for crossing · Reduced waiting time for pedestrians (through-traffic management measures) · Reduced physical effort (as few underpasses or pedestrian bridges as possible). · Possibility of crossing all along links with particular specifications (commercial streets, leisure areas): traffic management. · Adequate mutual visibility of pedestrians and drivers on the approaches to the crossing (through planning of parking facilities).	**Planning** · No underpasses or footbridges for elderly pedestrians, wheelchair users or partially disabled people.
	Design · Reduced risk for pedestrians when crossing in the right place (design must ensure that vehicle users behave as expected). · Local continuity of walking route and reduced physical effort (little denivellation between pavement or footpath and carriageway). · Reduced waiting time and long enough gaps in traffic for safe crossing (traffic light management); conflict-free crossing at traffic lights. · Adequate mutual visibility of pedestrians and drivers on the approaches to the crossing. · Possibility of crossing safely all along links with particular specifications (commercial streets, leisure or residential areas): reduced width of carriageway to cross or reduced speed of vehicles.	**Design** · Signals perceptible by blind people, indicating that they are approaching a crossing as well as the period when they can safely cross. · Denivellation between pavement or footpath and carriageway must be such that wheelchair users can cross it. · Sufficient crossing time for slow pedestrians (the elderly, partly disabled people). · Adequate visibility /detectability of children for drivers (in particular removal of parked cars near crossing).
	Maintenance · Keep the crossing facilities in good repair (especially markings). · Keep the approaches to the crossing clear of obstacles.	
Playing / Exercising	**Planning** · Provision of play areas in residential areas, and/or of mixed-traffic streets with very low speeds (30 km/h for example). · Reduced traffic flows on residential streets.	
	Design · Design of streets in residential areas ensuring very low speeds of vehicles.	**Design** · Good visibility of young children for drivers, particularly on residential streets and near schools.
Social interaction / Rest / Waiting	**Planning** · Provision of areas free of vehicles (“meeting points”) where people can stop, sit, talk together, etc. near the main pedestrians’ destinations.	
	Design · Adequate integration of “ meeting points” in the pedestrian routes (continuity). · Adequate design of “ meeting points” for attractiveness and comfort of social activities.	**Design** · Access to “meeting points” must be easy for elderly or disabled pedestrians.

5.4. Cyclists

The main principles for future planning for pedestrians also apply for cyclists. There is wide choice of non-restrictive measures. It is very important that restrictive measures be avoided, because they are incompatible with a new approach according to which maximum use should be made of cycling as a mode of transport. This is strongly motivated by health aspects. Most people in Europe do not take adequate daily physical exercise. An improvement in this situation would prevent diseases and the impact of this would far outweigh road safety problems. Moreover, in countries with a higher exposure of cyclists, the risks involved in cycling are smaller.

5.4.1. *Spatial proximity*

The spatial distribution of activities are a determining factor for both the need for travel and the distances to be covered. Long travel distances restrict the useability of the bicycle. For this reason it is necessary to develop land use planning that is based on the principle of 'proximity'. Large-scale transport infrastructures are themselves responsible for increased use of space, and they therefore impede 'proximity'-oriented land use planning.

5.4.2. *Planning for cycling as a mode of transport*

As is the case with motorised traffic, a network for the flow function is required. This network will not easily follow the network for through-motor traffic, since the mesh of the cycling network is smaller. So provisions for cycling should not be seen simply as an additional feature of the traffic structure for motor traffic.

A hierarchy of roads was developed according to function, design and behaviour for all modes of transport. It was based on the main requirements of coherence of the network, directness, safety, comfort and attractiveness on the one hand and on the new concepts for road safety on the other hand. The hierarchy was developed only for built-up areas and comprises 5 types:
1. Through-traffic route with a speed limit of 70 km/h and only grade-separated crossings,
2. Main street or urban arterial road with speed limit of 50 km/h and at intersections 30 km/h,
3. Residential street with a speed limit of 30 km/h,
4. Walking-speed street,
5. Car-free areas for pedestrians and cyclists.

5.4.3. *Design criteria*

When facilities for cyclists are being designed, five criteria are important if their needs are to be met:
- Safety: for large parts of the population in Europe (the perception of) road safety problems is a key reason for not cycling. Improvement of the safety of cyclists on the road is therefore a precondition for promotion of cycling.

- Coherence: continuity, consistency of quality, recognizability and completeness. It is obvious that cycling will be restricted if the cycle network is not complete or coherent. These are mainly features at network level.
- Directness: mean travel time, detours and delays.
- Comfort: smoothness of road surface, curves, gradients, number of stops between starting point and destination, complexity of rider's task.
- Attractiveness: visual quality of the road, surveyability, variety of environment and social safety. (Road safety measures might result in less visual quality and more [feelings of] insecurity, and thus be restrictive.)

Figure 5.5. *The village of Houten, the Netherlands, with its direct and attractive cycling connections*.

Figure 5.6. *Houten, the Netherlands.*

An elaboration of the hierarchy of roads and streets is given below:

1. Through-traffic route

Function

The through-traffic route is intended for longer car journeys through built-up areas passing by one or more residential areas. The routes consist of those roads where priority is given to the efficient transport of people and goods by car at steady, moderate speeds within a road network capable of handling the traffic volumes generally occurring in the network.

Design

The alignment of these roads is often of a high standard and as far away from buildings as possible. The carriageway often has two traffic lanes for car traffic in each direction, sometimes more. Pedestrians and cyclists are provided with grade-separated crossings for crossing these routes.

Behaviour

The speed limit for motor vehicles is mostly 70 km/h. The speed at intersections may not exceed 50 km/h if there is any risk of a side impact collision.

Walking and cycling

Pedestrians and cyclists pass these routes at grade-separated crossings. But the routes could easily constitute a barrier for bicycle and pedestrian traffic. Only frequent crossing possibilities (grade) can prevent the barrier effect. Therefore the number of routes of this type should be limited to prevent built-up areas being cut up into separate parts.

2. Main street

Function
A main street has a limit of 50 or 30 km per hour. It is used by motor vehicles and by cyclists travelling from one neighbourhood to another nearby or to a through-traffic road. Car parking can be permitted along such a street, especially in central areas.

Design
The carriageway normally has only two lanes for ordinary car traffic, one lane in each direction. The street also has wide cycle tracks and wide pedestrian pavements, affording pedestrians and cyclists good accessibility, safety and security. Intersections are provided with crossings for pedestrians and cyclists. Cycle tracks along these streets will almost of necessity become a natural link in the trunk bicycle network. This means that they will be at least 2 metres wide for one-way bicycle traffic and at least 4 metres wide for two-way bicycle traffic.

Behaviour
The speed limit is 50 km per hour but at intersections 30 km per hour.

Walking and cycling
There are three very important reasons for constructing cycle tracks along 50 km/h / 30 km/h streets. Firstly, this promotes cycling. The second reason is safety. The third reason is to enable road users to perceive intuitively that they are on a main street.

Figure 5.7. *"Wramstad": a design of a main street by Per Wramborg, Sweden.*

3. Residential street

Function
A residential street has a speed limit of 30 km per hour. It is a street in a residential area in which priority is given to the local inhabitants. The street should be an attractive, pleasant space and an environment suitable for

children, the elderly and disabled persons. As far as motor traffic is concerned, the street is used only by local traffic that originates in or has a destination within the neighbourhood. For cyclists, 30 km/h streets may have a distribution or a through-traffic function, since cyclists need smaller meshes in their network.

Design
Residential streets have pedestrian pavements and carriageways; some have a through-traffic function for cyclists. The carriageway is as narrow as possible, i.e., between four and six metres, to allow ample space for the pedestrian pavement.

Especially in the inner city areas, residential streets cater for part of the need for short-time parking. Parking spaces are designed and located with care to ensure that they might be aesthetically attractive elements within the street environment.

Behaviour
Within a residential area, it is normal for a pedestrian or a cyclist to cross a street anywhere along the street or at street crossings. A main route for cyclists and a cycle street can cut across a residential area. Such routes and cycle streets are characterised by distinctly more through-bicycle traffic than what can be found normally. The street may be one-way for cars. Mostly it is not necessary to make such a street one-way for cyclists as well.

4. Walking street

Function
The walking street is a communal outdoor space shared by everyone living by the street. It is a street especially for children, the elderly and disabled persons. The street is an attractive, pleasant space for meetings, play and recreation.

Design
The entire street is intended for everybody; it is not divided into separate lanes for different types of “traffic”.

Behaviour
Pedestrians and cyclists always have right of way.
The maximum speed for motor vehicles does not exceed walking speeds; i.e. 5 to 10 kilometres per hour.

5.4.4. *Crossing facilities*

Crossing facilities are needed on main streets. The design of crossing facilities is crucial. If best practice is not used, traffic safety can deteriorate. The safety of bicycle facilities is often reduced drastically by a lack of proper solutions at crossings.

Feelings of mutual respect can be promoted by right-of-way regulations, speed reduction measures and improved visibility. Examples of speed reduction measures are raised bicycle crossings, humps, refuges in crossings, and mini roundabouts. Important features for improvement of visibility are: truncated cycle tracks, advanced stop lines at signalised intersections, and parking regulations.

Figure 5.8. *Raised crossing, Denmark.*

5.4.5. *Regulations*

In the framework of development of non-restrictive measures for cyclists, regulations may make an important contribution to enhancement of the protection of cyclists and to enhance their right to make efficient and comfortable use of the road.

Regulations can enhance cycling policy for three reasons:
1. to set standards for safe behaviour of cyclists and road users who potentially put cyclists at risk,
2. to give a legal status to standards for a good combination of safety and mobility aims regarding cyclists,
3. to formulate the legal responsibilities in case of accidents.

Two main principles for highway codes and guidelines may be taken as a general approach:
- the waiting time for pedestrians and cyclists at crossings should be minimised, the pedestrians and cyclists being provided with the same rights as motor traffic,
- in urban areas, walking and cycling should receive first priority, except on some roads with a traffic flow function for cars only.

To ensure first priority for cyclists and pedestrians, technical measures are needed, supported by rules. Possibilities are:
- advanced stopping lines at crossings with traffic lights, to enable cyclists to wait in front of motor traffic and to continue first,
- leading phase for cyclists and pedestrians,
- traffic lights that provide a green phase to cyclists and pedestrians twice during each cycle,
- detectors that provide cyclists and pedestrians with green light as soon as they arrive at a crossing,
- providing cyclists with the right to turn right when motor traffic has to wait for a red light.

5.4.6. *Vehicle requirements*

Reliable and sustainable devices for bicycles make the requirements the most restrictive, because if the devices do not work properly or have to be repaired, the bicycle will be used less.

The potential of front reflectors for reduction of injuries in darkness has been estimated at about 4%. If the manufacturers were to agree on the requirements and install the reflectors on all bicycles, this could be a cost-effective measure.

Injuries to cyclists and pedestrians could be reduced by better design of cars and heavy vehicles. Design measures include soft noses on cars and side impact protection for trucks.

5.4.7. *helmets*

From the point of view of restrictiveness, even the official promotion of helmets may have negative consequences for bicycle use. If the importance of wearing a helmet is stressed, the implied message is that cycling is extraordinary dangerous. The report on cycling (PROMISING, 2001b) shows, however, that refraining from bicycle use has far greater negative consequences for health than increasing bicycle use without the wearing of helmets. To prevent helmets having a negative effect on the use of bicycles, the best approach is to leave the promotion to the manufacturers and shopkeepers.

5.4.8. *Education*

Education goes together with a comprehensive approach to road safety and mobility. Crucial factors for safe behaviour are:
- control of the vehicle by handling skills and defensive behaviour,
- control of situations by understanding of road conditions,
- understanding and communication,
- behavioural patterns.

Safety education can be combined very well with education about the advantages and benefits of cycling, and it is logical to combine these. The advantages of different modes of transport for the individual in terms of their efficiency in relation to trip length, purposes and conditions, in terms of health and in terms of safety in relation to the use of facilities, serve as a very good framework for traffic education. Besides, the benefits for society, the environment and the city climate and the benefits related to good use of available space, prevention of congestion etc. are very good subjects for education in primary and secondary schools.

The potential contribution of education to the safety of cyclists depends on more than just the education of the cyclists themselves. Education has an important role to play in creating co-operation between road users and enabling them to adapt to each other. For this reason driver instruction should cover characteristics of cyclists' behaviour and the anticipation of such it. Two central themes for an instruction program are recommended in this respect: adaptation of speed and learning to understand other road users and to 'communicate' with them.

Figure 5.9. *Cyclist instruction, the Netherlands*.

5.5. Motorised two-wheelers

The proposals for motorised two-wheelers fall into several categories. Better planning and design are required, as is research into the question of whether certain privileges that better take into account the characteristics of the vehicle/rider combination might be helpful in a transport setting. This is a non-restrictive approach.

Education of the riders themselves and of other road users is also mostly non-restrictive.

On the other hand, there is a need for defensive behaviour which might include vehicle modifications and stricter regulations regarding education and age limitation. These measures are more or less restrictive. Restriction of engine performance is clearly a restrictive measure, as is compulsory wearing of helmets.

A mix of restrictive and non-restrictive measures is necessary if the poor state of road safety is to be improved.

5.5.1. *Improvement of the infrastructure*

Road authorities have to become aware of the special needs of riders of mopeds/motorcycles in terms of the design and maintenance of the road. These riders are much more vulnerable to *imperfections* of the road surface than car drivers, and special requirements have to be recognised for road markings, road surface repairs, longitudinal grooves, drainage etc. Although many improvements to the design of roads and traffic control measures will have the same positive effect on the safety of riders of mopeds/motorcycles as on that of other road users, this is not the case with all speed-reducing measures. These measures may pose special problems for mopeds/motor-cycles and should be tested to prevent such problems. The same applies to the design and location of guard rails which may add to the injuries of riders of motorcycles/mopeds in the event of a collision.

Taking care of the needs of motorised two-wheelers fits into a non-restrictive approach. However, speed reduction measures also have to be reviewed to better guarantee that riders of motorised two-wheelers keep to the limit.

5.5.2. *Traffic rules*

Another aspect of a non-restrictive approach is to consider special traffic rules for motorised two-wheelers to provide the riders of these vehicles with some privileges. More use of two-wheelers may contribute to the solution of congestion problems. Examples of privileges are the possibilities of over-taking slow moving lines of cars and riding on lanes with limited access. Insofar as such lanes separate motorcycles/mopeds from cars, they could improve safety of these vehicles. On the other hand, it is also important to separate motorcycles and mopeds from cyclists and pedestrians. In the Netherlands, mopeds are banned from cycle facilities in urban areas for this reason.

There is little empirical information on the effects of such rules for motorised two-wheelers. Countries are recommended to evaluate such rules where they already exist and to promote demonstration projects to gain more experience with them.

5.5.3. *Vehicle improvements*

Vehicle improvements may be restrictive because they may add to the costs of riding. Over the years the handling, braking, lighting etc. of mopeds/motorcycles has much improved. But there is a continuous need for more development and research into improved control of brakes. At present, improved braking systems are available for expensive motorcycle models only.

Within limits, rider motivation and riding style have more effect than vehicle characteristics on accident rates. Because of this, the effects of further limiting engine performance will probably be minor. Significant effects can be expected only with drastic restrictions, such as the already existing lower speed of mopeds. But in some countries the tuning of mopeds to make them go faster is a serious safety problem, since their riders were not properly prepared for these higher speeds.

The perception of mopeds/motorcycles is a special problem for other road users. This can only be partly solved by the use of daytime headlights by riders of mopeds/motorcycles. This measure is estimated to reduce (daytime) collisions with cars by 30-40%. Given the present use of daytime headlights by motorcyclists in Europe, this translates into an estimated reduction of 7% of (daytime) collisions with cars and a reduction of some 140 motorcyclist fatalities per year (from a total of approx. 4,000). There is some concern that the effects will be less if cars have their lights on as well.

5.5.4. *Education*

Training and experience are important if the rider is to be able to control the moped/motorcycle in all kinds of situations, to cope with imperfect road surfaces and obstacles on the road, to recognise situations in which other road users may not react adequately to his or her presence, and to learn the consequences of behaviour which is different from that of car drivers and how to cope with these consequences. This is all in addition to what all road users or car drivers have to learn about safe behaviour. In other words, learning to ride a motorcycle safely may take longer and is to a certain extent different from learning to drive a car. Since mopeds have a lower speed, the above does not apply to the same extent for mopeds.

Countries with a relatively low minimum age for riding a moped or without compulsory training or licensing should reconsider this, either with or without the option of a low-speed moped with lower requirements.

Training programs should teach which actions and conditions are potentially dangerous. Insofar as these actions/conditions are part of the normal use of the road, riders will have to learn how to master them. The question is: which point during training is right for this: basic training, advanced training or later? Some actions/conditions are too difficult or too dangerous to learn before the rider has learned some basic knowledge and skills. Actions/ conditions which are not included in the compulsory training and testing of riders can still be learned by means of voluntary training programs or by experience. Countries should promote the availability of and participation in voluntary training programs. These programs could be based on examples from other countries such as Germany and the Netherlands and be aimed at different target groups of riders.

5.5.5. *Injury prevention*

The lack of protection of riders of mopeds/motorcycles can only partly be compensated for by wearing of a helmet or other protective clothing. Wearing of a helmet is compulsory for motorcyclists in all European countries. Actual wearing rates may be close to, but not exactly 100%. However, helmets are not always worn correctly, which may greatly reduce the protective effect. Some countries seem to have very low wearing rates (e.g. Greece with approx. 20%). The effects of wearing helmets are well documented: helmets reduce the risk of a fatality by half, with much scope for further improvement. Most countries also require moped riders to wear helmets, with the exception of Italy (only for riders 16-18 years), Belgium and the Netherlands (not for low-speed mopeds). Actual wearing rates for moped riders are not known all over Europe.

More research and development work is needed before other protective devices such as airbags and leg protectors can be introduced. In the future, cars and roadside obstacles will have to be designed to provide better protection for riders of mopeds/motorcycles who collide with them. Several studies have shown the adverse consequences of a motorcyclist colliding with a guard rail. New studies will lead to the development of better constructions and will identify locations which deserve priority treatment.

5.6. **Young drivers**

The measures recommended for young drivers are in general restrictive to their behaviour options. Lack of skills, inexperience, high exposure to difficult circumstances, and willingness to take risks are the main reasons why young car drivers face problems different from those of other car drivers.

The report on young drivers (PROMISING, 2001d) analysed the safety problems from a health angle. In that respect, there are two ways to combat the problems: reduced mobility as car users and reduced safety problems during use of a car. The fact that inexperience is an important risk factor points at an important difference between the safety and health aspects. Promotion of car mobility of young drivers to become more experienced, and thus reduce fatalities per kilometre driven, is not a good measure from a health perspective if this increases the absolute number of people killed in traffic.

5.6.1. *Reduced mobility by car*

Young people have a lifestyle which exposes them to critical traffic situations. They are also easily influenced by their passengers. Reduced car use is possible and has positive results. Evaluation studies show that alternatives such as disco buses and cheaper public transport - depending on their image and convenience - have a positive effect on road safety figures. Moreover, statistics show that for young drivers, cycling and walking are in general safer than driving.

If alternatives to car use are brought into line with the specific mobility needs of young people, the restrictiveness may be limited. Still, young people may have other opinions on the non-restrictiveness of alternatives, especially when they are primarily interested in driving because of the feeling of independence and maturity and the pleasure that it gives. A social marketing approach to the search for attractive measures is needed.

As long as measures promoting alternatives to the car are not made compulsory, these measures will be non-restrictive.

5.6.2. *Graduated licensing to combine opportunities for gaining experience with restrictions*

Another measure that would reduce car use by young people and thus lower the mortality rate would be to raise the minimum age for driving. This is a restrictive measure. There is no indication that there is political support for such a measure in Europe. On the contrary, there is a trend to start driving earlier, in an education framework. In young drivers, youth, lack of capabilities and inexperience coincide. Lack of capabilities and inexperience become evident in limited hazard perception skills, cognitive overload and incorrect vehicle handling routines.

Graduated or intermediate licensing systems are intended to provide a safe driving environment after the driving licence has been obtained. The time between driving test and graduation is divided into one or more phases in which only an intermediate driving licence is granted.

The extension of the learning period may be provided in combination with a lower age limit for starting the training. The age for obtaining a licence could remain the same. Granting of licences at a lower age cannot be justified. In Sweden, beneficial effects from lowering the age limit for training were found for the first year after the licence was obtained.

Driving simulators can now simulate complex traffic situations and stimulate the appropriate learning processes. They combat all risk factors associated with the inexperience of the novice driver. They give detailed feedback to the student. Another advantage is that driving skills can be divided in sub-actions, as a result of which they can be acquired more easily. Moreover, in a simulator, knowledge acquired in theoretical driving lessons can immediately be applied in a practical situation. Research must still be done into the question as to whether driving behaviour learned in a simulator is applied in a real driving situation.

The licence system may also be turned into an intermediate system, in which the full licence can be obtained only if the driver stays violation-free or observes restrictions such as a lower speed limit, accompanied driving, night curfews or a lower alcohol limit. The project group considers intermediate licensing with a zero BAC limit, voluntary night curfews and voluntary accompanied driving, as well as a second driving test after the intermediate period, to be the optimum solution. This combination of measures would take account of all risk factors. In addition, incorrect driving routines would become evident during the second test. Another advantage is that this system would provide an incentive for the novice driver to practice driving. Without such an incentive, the intermediate period could easily turn into a waiting period.

A zero BAC limit introduced in Austria showed good effects and there is wide support for this measure. Although the behaviour in respect of drinking and driving of young drivers is not worse than that of older drivers, drinking and driving is a very serious problem because of higher exposure of young drivers during weekend nights in combination with a lack of experience and the contribution of alcohol to the risks associated with driving. Apart from this, social measures (training of barmen, supportive measures for passengers), economic measures (pricing) and legal measures (increasing the legal drinking age, reduction of exposure during weekend nights) are promising measures.

5.6.3. *Speed reduction*

In other workpackages of this PROMISING project, it was shown that it is necessary to find a new balance in the priorities of the mobility and safety needs of different modes of transport. This means that measures that are restrictive for car drivers are in general necessary, because it is the car that received priority in the original planning and design. One of the most important measures in this respect is speed reduction. This measure will restrict the time efficiency of car driving only a little but will have a very significant positive effect both on the safety of the car drivers and on the safety and mobility of pedestrians and cyclists.

Speed reduction is possible by technical means. Telematics applications could provide solutions, but the development of instruments is not motivated primarily by safety. For the moment this is a theoretical option.

Speed reduction may also be considered in the framework of intermediate licensing. Environmental protection by means of voluntary measures may be emphasised in driver education. Many driving techniques that protect the environment enhance traffic safety at the same time, e.g. driving at 100 km/h, and many young drivers may accept this message more easily than the demand to drive more safely.

5.6.4. *Police enforcement*

The problem analysis shows clearly that young drivers are inclined to take more risks (e.g. one in three young male drivers admits to exceeding the speed limit on main roads) and less inclined to use protective measures such as seat belts. Restrictive measures are thus urgently necessary, not only for protection of the drivers but also for that of society. Road safety policy includes the possibility of enforcement by the police.

The opinions of the young people on the restrictiveness of such measures vary. On one hand, young people tend to say that they know what they are doing and appeal for freedom to drive as they wish. On the other hand, they support enforcement measures no less than other drivers do.

As a means of rewarding safe behaviour, lower insurance fees are suggested. This as an alternative to penalties for unsafe behaviour.

5.6.5. *Personal interventions*

The problem analysis also makes it clear that personality traits play a role for about 30% of the target group. A relationship between sensation-seeking and a dangerous driving style has repeatedly been found.

The so-called lifestyle approach abandons the individual level and emphasises the group level. The aim is to identify subgroups in which various risk factors are present and to characterise them by other features besides the risk factors. Due to the fact that young car drivers do not form a uniform group with homogeneous behaviour patterns but various heterogeneous subgroups with specific behaviour structures, a universal approach to the adolescent age group would seem to be inappropriate.

Since sensation-seeking is a personality trait, it not only leads to a dangerous driving style but also shows in other aspects of life, constituting the so-called risk syndrome. The lifestyle approach could show that risk syndromes concentrate in groups with certain leisure time preferences. These groups must be identified before they can be addressed by campaigns or traffic education programs in schools. Repeated studies in the field of lifestyle research confirm that leisure activities and lifestyle and their combination with traffic-related attitudes and behaviour, including accident involvement, show a remarkable stability throughout a person’s life. Therefore correction of unsafe behaviour should take place at a very early stage of socialisation.

5.6.6. *An overview of evaluation studies*

Table 5.2 presents an overview of the measures that have been reviewed, categorised by their restrictiveness or non-restrictiveness and their technical or non-technical character. The first column of *Table 5.2* gives the measures, which are sorted into 4 categories: technical restrictive, technical non-restrictive, non-technical restrictive, non-technical non-restrictive. The risk factors addressed by the countermeasures are given in the second column. The third column assigns the risk factors to the problem groups, and the last column gives the evaluation result: it is indicated if evaluations studies of the respective countermeasure were mostly positive (+), negative (-), or contradictory (+-). If no evaluation studies for young drivers were mentioned in the literature analysed, this is indicated by a ”none” in the respective cell.

Countermeasure	Risk factors	Problem group			Evaluation result
		Age	Inexpe-rience	Risk-seeking personality	
Technical restrictive countermeasures					
Graduated licensing with restrictions: vehicle with limited horsepower	- Cognitive overload		X		None
Technical non-restrictive countermeasures					
Driver education: driving simulator	- Inexperience		X		+
Non-technical restrictive measures					
Intermediate licensing	- Risk utility			X	+
Additional driving courses	- Incorrect driving routines - Risk-seeking		X	 X	+-
Intermediate licensing with speed limit	- Cognitive overload		X		+-
Intermediate licensing with night curfews	- Exposure to dangerous traffic situations - Cognitive overload - Limited hazard perception skills	X	 X X		+
Intermediate licensing with zero BAC	- Cognitive overload - Limited hazard perception skills - Risk-seeking		X X	 X	+-
Intermediate licensing without passengers	- Influence of passengers - Cognitive overload	X	 X		None
Intermediate licensing: combinations	- See single components of combination	X	X	X	+
Two-phase driver education	- Limited hazard perception skills - Incorrect driving routines		X X		+-
Accompanied driving: private driving tuition	- Cognitive overload - Incorrect driving routines - Limited hazard perception skills - Overestimation of ability		X X X X		-
Accompanied driving: apprenticeship	- Cognitive overload - Incorrect driving routines - Limited hazard perception skills - Overestimation of ability		X X X X		+-
Intermediate licensing with 2nd driving test and restrictions during probation	- Exposure to dangerous traffic situations - Cognitive overload - Limited hazard perception skills - Incorrect driving routines - Overestimation of ability - Risk-seeking - Risk utility	X	 X X X X	 X X	None
Stricter and more frequent police controls	- Risk utility			X	None
Prohibition of aggressive car advertisements	- Risk-seeking - Extra motives			X X	

Countermeasure	Risk factors	Problem group			Evaluation result
		Age	**Inexpe-rience**	**Risk-seeking personality**	
Non-technical non-restrictive measures					
Higher licensing age	- All juvenile specific risk factors	X			+-
Education: intensification	- Incorrect driving routines		X		-
Education: hazard perception training	- Limited hazard perception skills		X		+-
Education: limitation training	- Overestimation of own abilities		X		+
Education: training of driving skills	- Cognitive overload		X		-
Education: commentary driving	- Limited hazard perception skills - Incorrect driving routines		X X		None
Education: protection of environment	- Risk utility (indirect)			X	None
More intensive pedagogical education of driving instructors	- Target not specified	?	?	?	None
EU-wide guidelines for driver education/test	- Target not specified	?	?	?	None
Quality standards for driving schools	- Target not specified	?	?	?	None
EU-standardised psychological tests, obligatory second training for accident drivers	- Incorrect driving routines - Risk-seeking		X	 X	None
Campaigns	- Influence of passenger - Limited hazard perception skills - Risk-seeking - Risk utility - Risky lifestyle	X	 X	 X X X	None
Traffic education in schools	- Influence of passenger - Limited hazard perception skills - Risk-seeking - Risk utility - Risky lifestyle	X X	 X X X	+-	
Alternative transportation offers	- Exposure to dangerous traffic situations	X			-
Lower insurance fees	- Risk utility			X	+
Cheap non-alcoholic drinks	- Socio-economic status - Alcohol consumption			X X	None

Table 5.2. *Measures for reduction of accident risk among young drivers. In the last column it is indicated if evaluations studies of the respective countermeasure were mostly positive (+), negative (-), or contradictory (+-). If no evaluation studies for young drivers were mentioned in the literature analysed, this is indicated by a "none" in the respective cell (from PROMISING, 2001d).*

6. Results of cost-benefit analysis

6.1. The methodology

Cost-benefit analysis is a technique designed to help policy-makers find the most efficient way of realising policy objectives. It supposes that different policy options are compared to find the best solution for these objectives. If the expected consequences are calculated, the most cost-beneficial package of measures to realise policy objectives can be chosen.

It is not common to formulate all possible policy options every time when political decisions have to be made, due to a lack of time and a lack of good data. This may lead to underestimation of the possibilities of cost-benefit analyses in decision making. But it is logical that the advantages of such an analysis must always be balanced against the costs. Even the method of cost-benefit analysis has to be analysed in terms of its costs and benefits.

Nevertheless, it is seen that the political debate demands more and more results from cost-benefit analyses because of the often huge costs of measures to be taken and the many demands from society for improvement of the standard of living and social activities and preservation of the environment and cultural heritage.

In the framework of new policy directions for traffic and transport, the EU asked not only for development of measures that enhance the safety and mobility of vulnerable road users, but also for calculation of the cost-benefit ratios of measures.

In the PROMISING project, the methodology has been described and the cost-benefit ratios of 20 measures have been calculated. These were single measures. It is already very difficult to get good data on the exposure and risk of injury of a certain amount of travel and, related to this, the effects of measures on the travel efficiency and safety. The requirement to assign monetary values will restrict the application of cost-benefit analysis to measures whose effects are well known and situations in which policy objectives are clearly articulated and widely supported. This limited the selection of measures for the analysis. The analyses presented are in most cases based on data taken from one country.

It limits also the selection of combinations of measures. On a more strategic level, it would be interesting to find out what it means for a city when it plans for e.g. a growth of non-motorised transport by 100%, with as a consequence a reduced need to plan for motorised transport. In principle, such a cost-benefit analysis is possible by calculation of the costs for achievement of this goal, the reduction in investments for motorised transport, and the effects on road safety and other health conditions, on transport efficiency, on the social and economic climate of the city etc. This kind of calculation was not included in the scope of this project.

Cost-benefit analysis is a subject of new projects in the 5th framework for EU research. The results from the PROMISING show there is clearly a need for more and other kind of data.

6.2. Results

Cost-benefit analyses have been made of the following measures designed to improve safety and mobility for vulnerable and inexperienced road users:

- roundabouts,
- road lighting,
- integrated area-wide urban speed reduction schemes,
- environmentally adapted through-roads,
- upgrading pedestrian crossings,
- parking regulations,
- front, side and rear underrun guard rails on trucks,
- local bicycle policy to encourage mode switching from car driving,
- bicycle lanes,
- bicycle paths,
- advanced stop lines for bicycles at junctions,
- mandatory wearing of bicycle helmets,
- improving bicycle conspicuity,
- daytime running lights on cars,
- daytime running lights on mopeds and motorcycles,
- mandatory wearing of helmets for moped and motorcycle riders,
- design changes on motorcycles,
- graduated licensing – lowered age limit for driver training,
- license on probation – lowered BAC limit for novice drivers,
- disco buses.

Roundabouts

Modern roundabouts are designed according to the offside priority rule. This regulation serve to reduce speed. Moreover, the task of road users entering the roundabout is simplified. Roundabouts have therefore lead to substantial improvements in safety.

In addition, roundabouts have greater capacity than junctions controlled by give way signs or traffic signals. No effects on pollution have been assumed, although in junctions with a high traffic volume, a certain reductions in vehicle emissions can be expected.

To illustrate the way the calculations have been performed, we present the results in detail in *Table 6.1*. A discount rate of five percent has been used. A time horizon of 25 years is used. This means that the present value of benefits equals 14.094 times the first year benefits. The results of the analysis are given in Norwegian kroner (NOK).

Assumptions made and results of analysis	Number of legs in junction	
	Three legs	Four legs
Annual average daily traffic (typical value)	7,500	15,000
Injury accidents per million entering vehicles	0.10	0.15
Expected annual number of accidents	0.27	0.82
Effect on accidents of converting to roundabout	-25%	-35%
Annual number of prevented accidents	0.07	0.29
Present value of accident cost savings (25 yrs, 5%)	1,540,000	6,480,000
Travel time change per entering vehicle (seconds)	0	-3
Present value of travel time savings	0	6,430,000
Total benefits	1,540,000	12,910,000
Costs of installing roundabout (investment)	1,250,000	1,500,000
Benefit/cost ratio	1.23	8.61

Table 6.1. *Assumptions and the results of the cost-benefit analysis of installing a roundabout (from PROMISING, 2001e).*

It is seen in *Table 6.1* that converting junctions to roundabouts gives benefits that exceed the costs under the assumptions made. In general, a roundabout is a good solution for junctions with a daily traffic of more than about 5,000 vehicles. Benefits exceed costs irrespective of whether travel time savings are included or not. The effects on travel time are therefore not decisive for the results of the analysis. Benefits would exceed costs even if there were a slight increase in travel time.

Roundabouts reduce the number of pedestrian accident by the same percentage as all other accidents (Elvik, Mysen & Vaa, 1997). As far as bicycle accidents are concerned, the effect appears to be somewhat smaller, in the order of 10-20% reduction in the number of accidents.

Road lighting

Road lighting is particularly effective in reducing fatal accidents and accidents involving pedestrians. Since these types of accident involve higher costs than the average accident, road lighting gives large savings in accident costs. The effects on safety of installing road lighting vary, depending on the previous level of illumination and the quality of lighting.

Integrated area-wide speed reduction measures

Driving speed has a major effect on the probability of becoming involved in an accident and on the severity of injuries once the accident has occurred. The lower the driving speed, the smaller becomes the chances of accidents involving serious injury to pedestrians or cyclists.

UK experience shows that traffic volume was reduced in all areas studied, varying from 1% to 18%. Mean speed was sharply reduced, from 32.0 to 20.5 miles/h (36% reduction) in town centres, from 43.2 to 34.5 miles/h (20% reduction) on rural main roads, and from 35.6 to 23.5 miles/h (34%

reduction) in residential areas. The number of injury accidents was reduced by 50 to 70%.

When all effects are summarised, the net benefits are positive in town centres and residential areas, but negative on rural main roads. The fact that net benefits turn out to be negative on rural main roads is mainly due to the large increases in the costs of travel time. These results illustrate several troublesome aspects of current cost-benefit analyses:

First, there is no information on how the schemes affected accident severity. In general, however, a speed reduction will reduce accident severity.

Second, detailed knowledge of the composition of traffic by type of vehicle and trip purpose by type of area is needed in order to account for these differences in a cost-benefit analysis.

Third, the effects of the speed reducing measures are evaluated strictly from a road user point of view. When car drivers are forced to slow down, that counts as an added cost. An important objective of speed reducing measures is to improve conditions for those who live or work in an area, or for those groups of road users who do not drive a car. Less motor traffic means less noise and pollution. It also means that crossing the road becomes easier. A cost-benefit analysis that does not include these benefits is incomplete and one-sided. It favours car drivers' point of view and interests at the expense of those who do not drive.

In a wider perspective, one may wonder how a long-term target of curbing the use of cars in the interest of environmental sustainability can fit into the current framework for cost-benefit analysis. Measures that reduce motor traffic, either by raising the direct costs or by slowing traffic down, will often fail a cost-benefit test, because less traffic counts as a negative benefit. In this sense, cost-benefit analysis can hardly be said to be neutral with respect to long-term policy objectives. Reduced cost and increased demand always counts as a benefit in cost-benefit analysis, whereas a reduction in demand – ceteris paribus – counts as a loss of benefit. Policies that aim to reduce travel demand are very difficult to justify by means of cost-benefit analysis. Yet it may be precisely such policies that are needed in order to promote a sustainable transport system.

Environmentally adapted through-roads

An environmentally adapted through-road is a main road passing through a village or small town which has been modified in order to reduce speed and improve the environment. Roads are reconstructed by providing humps or raised pedestrian crossings, by widening the pavement and narrowing the driving lanes, by planting flowers and trees to make the road look nicer, by regulating parking more strictly and by introducing other measures that are intended to beautify the road and its closest surroundings.

Accident costs are reduced, but all other travel costs are increased. Speed is reduced, leading to an increase in travel time costs. Once again, this kind of result leaves one wondering if there is something seriously wrong with the current framework for cost-benefit analysis. Briefly speaking, current cost-benefit analyses of road projects are based on the preferences of road users. It should not come as a great surprise that road users want cheap and fast transport, and that everything that makes it more expensive to travel or slows travel down is hardly perceived as an improvement from the traveller's point of view. But this perspective is one-sided. Travel has substantial negative effects on the environment. Although these "external effects of transport", as they are referred to in economic jargon, are supposed to be included in the above cost-benefit analysis, one may doubt if they have been given sufficient weight.

Since both a public road and a cleaner environment are public goods, one cannot settle the matter by assigning formal rights of ownership to these goods in the same way, as private goods are individually owned. It is ultimately a matter of how one defines the rights citizens are entitled to exercise in a democratic society. It is beyond the scope of this report to settle such constitutional issues.

Upgrading pedestrian crossings

Ordinary marked pedestrian crossings, which are common in urban areas, do not improve safety. A number of measures can be introduced, however, to counteract this tendency. Road lighting, refuges, safety fences and raised pedestrian crossings all improve safety. Road lighting was discussed above. A package of measures, including, for example a raised pedestrian crossing and safety fences, is likely to reduce the number of pedestrian accidents at pedestrian crossings by about 60% and the number of vehicle accidents by about 35%.

Figure 6.1. *Raised pedestrian crossing in Utrecht, the Netherlands.*

The measure gives a positive net benefit for pedestrians, but a negative net benefit for motor vehicles. When the effects are summed for these two groups of road users, the net benefit is negative. This case illustrates the fact that there can be a conflict of interest between various road user groups in urban traffic. The term "efficient" as used here denotes a change for which the benefits exceed the costs, as valued by the people who benefit or who incur the costs. This concept is the one underlying cost-benefit analysis. It does not embody notions of fairness, for example. If, for example, one considers it unfair that cars impose delays on pedestrians, then the above calculations are less relevant.

Parking regulations

Parked cars are a traffic hazard for pedestrians, particularly children. Research has shown that prohibiting on-street parking improves safety. The number of accidents is reduced by about 25% in streets where on-street parking is prohibited.

The savings in accident costs are less than the costs of constructing the garage. Incurring this cost therefore cannot be defended by reference to safety effects alone. Garage parking does, however, provide other advantages to car owners. By renting space in a garage, one is always guaranteed a parking space. Theft of the car may be less likely and leaving it parked for a long time may be less of a problem than it is when parking on-street.

Front, rear and side underrun guard rails on trucks

Protecting all sides of trucks by means of energy absorbing devices with a low ground clearance (best currently available technology) is expected to reduce the number of fatal injuries by about 12%. If it is assumed that the cost of accidents is reduced 10% per year, these costs easily exceeds the cost of providing protection against underriding. Benefits would exceed costs even if the safety effect was as small as 5%. It would therefore seem to be a good idea to provide trucks with protection against underriding.

Local bicycle policy to encourage mode switching

Car driving imposes external costs on society. By external costs are meant all costs that are not taken into account by drivers, and are, effectively, treated as zero costs. The major categories of external costs caused by motor travel include:

- costs of air pollution,
- costs of traffic noise,
- part of the costs of traffic congestion,
- part of the costs of injury accidents.

These costs are all related to unintended negative effects of transport and do, to a major extent, not have market prices. It is difficult to estimate the external costs of motor transport and no international consensus estimate exists. Depending on how costs are estimated, and which items are included, it is therefore possible to arrive at very different results.

Cycling does not generate the same external costs as car driving. The major item in the external costs of cycling is likely to be accident costs. Contrary to motorised transport, cycling may generate external benefits, not just external costs. The external benefits of cycling may include, for example, the savings in public health care spending obtained if the general physical fitness of the population improves as a result of more cycling.

In order to gain an impression as to whether it would make sense at all to try to make car drivers choose cycling instead of driving, an estimate of the external costs of car driving and cycling has been presented. The conclusion is that it would make sense from an economic point of view to encourage cycling.

Figure 6.2. *Walking and cycling street in Groningen, the Netherlands.*

Bicycle lanes

Bicycle lanes are a cheap and effective way of improving the conditions for cyclists in urban areas. There is conflicting evidence on the safety effects of bicycle lanes, depending on their design and on solutions at intersections.

In the cost-benefit analysis, it has been assumed that the provision of cycle lanes reduces the number of bicycle accidents by 10% and, in addition to that, reduces the generalised costs of travel for cyclists by 20%(excluding that part of these costs related to accidents). This is assumed to lead to a 15% increase in cycling. For motor traffic and pedestrians, a reduction in accidents of 30% is assumed. Speed is assumed to go down about 5%, from a mean of 50 km/h before the measure to 47.5 km/h after.

Some highly preliminary estimates of the generalised costs of travel for pedestrians and cyclists, and some elements of those costs, were based on the findings of the WALCYNG project. Since none of these costs have so far been estimated in other studies, they are used for illustrative purposes only.

It turns out that the benefits of the savings in the generalised costs of cycling, and the attendant induced cycling, are far greater than the savings in accident costs.

Advanced stop lines for cycles at junctions

Advanced stop lines for cycles at junctions have been found to reduce the number of accidents. In addition, it has been argued that advanced stop lines will reduce cyclist exposure to pollution from automobiles.

The analysis indicates that the benefits are greater than the costs by a wide margin. This conclusion applies even if the non-safety related effects of the measure are disregarded. The estimated benefit of reduced exposure to pollution, in particular, is surprisingly large.

Mandatory wearing of bicycle helmets

Mandatory wearing of bicycle helmets has been introduced in Australia, New Zealand and some of states of the United States. The evaluation studies that have been made indicate that a law requiring cyclists to wear helmets generates three effects (Elvik, Mysen & Vaa, 1997):

- *the helmet effect*, which reduces the likelihood of sustaining a head injury in an accident. This effect manifests itself in a reduction in the proportion of all injuries to cyclists that are head injuries.
- *the behavioural adaptation effect*, which means that some cyclists may cycle less carefully when they feel protected by a helmet than when they do not wear one. This effect manifests itself in an increase in the accident rate per kilometre of cycling once helmets become more commonly used.
- *the exposure effect*, which means that some people stop cycling when helmet wearing becomes the law. This effect manifests itself in a reduction in the number of kilometres cycled once helmet wearing is made mandatory.

Laws requiring the wearing of helmets are controversial and not always popular among cyclists. Such laws may actually be harmful to public health, because the lack of exercise resulting from a reduction in cycling increases the risk of disease more than the reduction in head injuries brought about by increased helmet wearing.

It is concluded that the assumptions one would have to make to do a cost-benefit analysis of mandatory bicycle helmet wearing are still too uncertain for such an analysis to make sense.

Improving bicycle conspicuity

Darkness is a major risk factor for cyclists. Reflective devices on the bicycle or the rider can improve conspicuity substantially and thereby make bicycles easier to detect and identify.

The effects vary greatly from one type of device to another. If we assume that a combination of devices reduces the number of multi-party accidents in darkness by 50%, the benefits are nearly equal to the assumed costs of the measures.

Daytime running lights on cars

Daytime running lights is an effective accident countermeasure that is being introduced in more and more countries (Elvik, 1996). It is, however, a controversial measure, especially with respect to the effects on accidents involving pedestrians or cyclists. It has been argued, for example, that a widespread use of headlights on motor vehicles would tend to make pedestrians and cyclists comparatively less conspicuous and thus more easy to overlook.

It is seen that no matter how one measures the effects of daytime running lights, the number of pedestrian accidents is reduced. The reduction is between 10 and 20%. The number of bicycle accidents is also reduced. Depending on how effects are measured, the reduction ranges from 2% to 19%. There is no doubt that the benefits of this measure clearly exceed the costs.

Daytime running lights on motorcycles

Motorcycles are less easy to see than cars because they are smaller. It is well established that poor conspicuity is a contributory factor in many accidents involving motorcycles. It is therefore reasonable to expect the compulsory use of daytime running lights on motorcycles to improve conspicuity and reduce the number of accidents.

Motorcycles that use daytime running lights have an accident rate which is about 10% lower than motorcycles that do not use daytime running lights. It is quite likely that the benefits of requiring mopeds and motorcycles to use daytime running lights will exceed the costs in most European countries.

Mandatory wearing of helmets for moped and motorcycle riders

The wearing of helmets is mandatory for riders of mopeds and motorcycles in most European countries. There are, however, still a few exceptions to this rule.

Wearing a helmet makes a major difference to the risk of injury for a moped or motorcycle rider. Assuming that the helmet is written off in five years, benefits widely exceed costs. This result is not surprising. All cost-benefit analyses of crash helmets that have been reported in the literature come to the same conclusion.

Design changes on motorcycles

Slightly changing the design of motorcycles could reduce the risk of injury. Among the design changes that have been shown to reduce the risk of injury are:
- slightly prolonging the front wheel fork,
- constructing a frangible footrest, which is torn off when it touches the ground,
- slightly lowering the seat,
- providing a windshield,
- providing a fairing to protect knees and legs.

A conservative estimate of the combined effect of these design changes on injury probability is 25% reduction. The costs are not well known. Assuming an average cost of 100,000 ECU per injury, the present value for a ten year time horizon of a 25% reduction in injury risk at this level of is 1,930 ECU per motorcyclist. This means that if the design changes cost more than this amount per motorcycle, and if they have an effect only on safety, the benefits will be smaller than the costs.

Graduated licensing systems – lowered age limit for driver training in Sweden

In 1993, Sweden introduced a new lower age limit for starting driver training. The age at which training was permitted was reduced from 17½ years to 16 years. The licensing age remained 18 years. The objective of this reform was to give novice driver more opportunities for training before becoming fully licensed drivers.

The evaluation found a reduction of 35% in the injury accident rate of those who started driver training at 16 compared to those who started at 17½. The savings in accident costs obtained during the first year of driving outweigh the additional costs of training. It seems likely, though, that any effect during the second and third years of driving will be smaller than during the first year of driving. Moreover, the true effects of the additional training may be smaller than assumed in this calculation, due to the selective recruitment effect adduced to above.

Graduated driver license – license on probation in Austria

In recent years, several countries have introduced a graduated licensing system for new drivers. One version of such a system – driver's license on probation – was introduced in Austria in 1992. The law prescribes a probation period of two years for novice drivers. In addition the legal BAC limit for novice drivers was lowered from 0.08% to 0.01%. For other drivers, the legal BAC-limit was not changed. During the probation period, the following offences lead to an obligatory participation in a driver improvement programme as well as to an extension of the two-year period of probation for an additional year:

- offence against the 0.01% BAC limit,
- causing an injury or fatality,
- committing a dangerous offence, for example, seriously exceeding the speed limits.

The results indicate a 32.5% decrease in the number of accidents within the group of novice drivers. The decrease within the group of all the other drivers was merely 8.9% in the same period.

In the year of the introduction of this law (1992) 19.2% fewer new licences were issued compared to the year before. Even taking into account this reducing number of novice drivers, the analysis still indicates an accident reduction of 18.7% (number of novice drivers involved in accidents with personal injuries and fatalities related to the number of holders of driving licences on probation). The benefits outweigh the costs by a wide margin.

Disco buses in Germany

In order to reduce the high number of late-night road accidents among 18 to 24-year-olds at weekends, numerous public transport services, in particular disco buses, have been set up in Germany since the early 1990s. The disco buses are intended to contribute to road safety is by offering a safe alternative to young people unfit to drive (especially due to alcohol) and to young people dependent on taking lifts from unfit drivers. Data about these

bus services were collected by BASt for the PROMISING project.
The benefits exceed the costs by a wide margin.

6.3. Summary

The results from the analysis, although based on data of single measures of one country, were such, that it is possible to formulate some general conclusions.

- Measures that *reduce driving speed*, especially in urban areas, will improve safety, and sometimes mobility, for pedestrians and cyclists, but more kinds of benefits have to be included in the analysis.

- The benefits of *facilities for pedestrians and cyclists* exceed costs by a wide margin.

- Measures that *improve conspicuity and visibility* are cost beneficial.

- The implementation of measures regarding *injury protection* underrun guard rails and helmet wearing for motorised two-wheelers.

- Graduated licensing and *driver's licence on probation*, *including a lower BAC limit of 0.01%,* are promising measures for inexperienced drivers.

7. Implementation strategies

7.1. Main focus on planning and/or training

The results of the analyses to find measures for the different target groups show one important difference for pedestrians and cyclists as compared with motorcycle and moped riders and young drivers. For pedestrians and cyclists, the measures consist mainly of better planning of the transport and traffic system with consideration to walking and cycling as modes of transport. This has consequences for the design of road facilities. An integrated approach, creating also a better balance between the interests of pedestrians and cyclist and those of motorists, is recommended. Although single measures may still be effective, isolated safety measures of one single type usually do not go very far in reducing safety and mobility problems. It is considered more advisable to look, as far as possible, for balanced and comprehensive solutions rather than to seek a one-to-one correspondence between problems and countermeasures. Regulations and education should fit with this approach.

The report on pedestrians (PROMISING, 2001a) described an implementation strategy as consisting of the following steps:

- *Identification and understanding of pedestrian safety problems:* This may take place at various levels, for example concerning a whole country or a specific part of a town.
- *Selection of relevant safety actions and measures:* This is made from the "pool" of 26 actions and 100 measures for pedestrian safety, identified in the project.
- *Definition of implementation conditions:* These arise from case-specific analyses.
- *Three-step implementation process:* It consists of *strategy, preparation* and *execution*.
- *Pedestrian safety improvement and feedback:* The result of the implementation is fed back to the overall understanding of pedestrian safety problems.

Policy makers will have to recognise the role of moped riders and motorcyclists as road users and the need for measures to improve their safety. The question arises as to whether their position should also be improved in view of the fact that these modes of transport are an alternative to the motorcar. There is an argument for encouraging use of mopeds and motorcyclist as a means of reducing congestion; increased use of these modes will, however, cause road safety to deteriorate. The design of road facilities should be adapted to correspond to the characteristics of two-wheelers. But most efforts to improve the situation of motorcycle and moped riders will have to involve training and injury protection.

For young drivers, a better system of training in combination with behavioural restrictions and transport alternatives is recommended.

7.2. Local and national solutions

A general feature of the implementation of a better balance between modes of transport (the PROMISING approach) is a changed transport and traffic policy, which of course includes the distribution of investments.
The context, that is the transport, political, technical, economical and cultural environment, will determine which solutions are most suitable locally, regionally and nationally. Principles can be applied but have to be transformed into concrete measures.

If an approach is to be implemented and new measures to be introduced, the following factors should be taken into account:

- tradition in transport and traffic policies,
- perception of current traffic problems,
- political support from outside, e.g. from interest groups,
- political willpower, greatly influenced by problem perceptions and political support,
- personnel capacity,
- plans and acknowledgement of the need for planning,
- integration with other policies, which is much influenced by capacity and plans,
- budgets.

7.3. Cooperation between governments on different levels

Especially for planning reasons, implementation requires co-operation between local authorities and the national government or administration.
In many cases, the central administration may provide support to the local initiatives (through regulations, incentives, expertise, follow up and information gathering). Conversely, local initiatives may complement national action and give it more prominence at the local level (in safety campaigns, educational issues, etc.).

The international level cannot be disregarded. On this level also, support to good local initiatives is possible by rewarding the recommended approach with subsidies. It is also becoming important to harmonise the travelling conditions in order to facilitate the adaptation of road users who move from one country to another and to give equal treatment to pedestrians, especially with regard to their legal rights.

7.4. Target setting

Target setting is a good way of establishing what has to be done to plan for the future. It makes clear what kind of resources we need to bring in, what kind of tools we need for good planning, and it directs our activities also to the search for an effective and efficient approach.

Setting targets and planning can not be fruitful if success and failures are not monitored. Monitoring is an instrument for adaptation of policies when they are not as effective as predicted, for remaining flexible, which is necessary since external factors may change, and for keeping all parties alert and involved. Showing progress is of course a very important stimulus for continuation of a policy.

7.5. Involving the road users

A further common recommendation for all groups is to involve the road users or their representatives in the planning process. The analyses made clear that their needs have not been taken into account in planning and the design of facilities. The best way to establish whether measures will work and whether they will provoke a good use of facilities and the right behaviour is involvement.

Figure 7.1. *"Dear cyclists, the municipality of Paris interviews here about the conditions for bicycle traffic. Thank you for halting".*

Training of riders of mopeds/motorcycles and of young drivers depends to a large extent on the willingness of riders to accept the measures and to improve their behaviour. Acceptance of a measure is much better if the target group has been involved in the development and introduction of the measure. The same argument is valid for providing transport alternatives to the car. These should be attractive and convenient; whether they actually are is something only the users can tell.

Because of society's mobility requirements, the economic function of mobility, and the impact of traffic on use of space and on the social climate and the environment, it is also important to involve communities and different interest groups in the design of the transport and traffic system.

7.6. Capacity building

It is clear that the task of professionals involved in traffic and transport is not easy and requires a vast basis of knowledge (understanding of accident and mobility generation processes) and know-how (experience in measures and programmes). New policies for sustainable transport that are to focus on the non-motorised road users are particularly difficult to manage, as the parties concerned have little experience in this field.

There is a need to train professionals in road safety matters at all levels, and to keep upgrading the training as experience grows and attitudes change. This will be possible only through establishment of networks of professionals for teaching of methodologies and know-how and dissemination of an up-to-date "road safety culture".

Figure 7.2. *Utrecht, the Netherlands.*

Figure 7.3. *Houten, the Netherlands.*

In this training of professionals three aspects need to be addressed. Firstly to make sure that those coming into the profession fully appreciate the policy needs and all the practical necessities of planning for different groups of road users. Secondly to ensure that those already in the profession maintain their skill levels and keep abreast of the latest developments. Best practice can change very quickly. Lastly there is a need to raise the status of those in the profession so that good-quality people are tempted to come into the profession in the first place, and stay in it knowing that they have sufficient chances for promotion.

At an international level, opportunities to exchange information and results on (pedestrian) safety policies are most welcome, as comparative studies of initiatives and new measures in different countries can boost interest and provide know-how for improvements. Cooperation on regulations and measures has still to be developed.

7.7. Data

Mobility and safety patterns vary greatly through Europe. There is a certain need for harmonisation, in particular because many people participate in road traffic outside their own countries.

So that maximum benefits can be achieved, data collection should be improved. A better understanding of problems and the value of solutions is hindered by a lack of appropriate data of sufficient quality.

It would be an improvement if data on risks are related to transport needs and trips, instead of to kilometres only. From the point of view of health, safety standards should be put in relation to travel needs.

If the value of cost-benefit analyses is to be improved, harmonisation of data is also a must. Not only data regarding mobility and safety are important; other kinds of data relating to the benefits and negative consequences of traffic and transport for matters such as health, social functions, local economies and the environment should also be considered.

8. Conclusions

8.1. The approach

The aim of the PROMISING project was to develop measures that reduce the risk of injury to vulnerable road users as much as possible in a non-restrictive way. Safety and mobility were to be improved together. EU DGVII asked for a policy-oriented report, widely illustrated with photographs and good examples.

Four groups of vulnerable road users were distinguished: pedestrians, cyclists, riders of motorised two-wheelers, and young car drivers.
The common approach for these groups was to analyse safety problems, to make an inventory of measures and to evaluate the restrictiveness and the costs and benefits of the measures.

However, the approach differed in some respects. The workpackages concerning pedestrians and cyclists started by taking walking and cycling as a mode of transport and combined transport criteria with safety criteria.
The workpackeges concerning motorised two-wheelers and young drivers selected the most important safety measures and considered mobility aspects of these measures.

The PROMISING project paid much attention to the effectiveness of measures.

8.2. Safety analysis

The vulnerability of the body plays an important role in explaining the risk differences between the different modes of transport. Car occupants are protected to a certain extent by their vehicles. The damage caused by a collision is a consequence of mass and speed.

One reason for the high risk of motorised two-wheelers is that they are single-track vehicles. The rider has difficulty controlling the vehicle, in particular when cornering or braking, and even more so in emergency situations. It also means that the rider has more difficulty coping with imperfect road surfaces and obstacles on the road.

The greater safety problems of two-wheelers and pedestrians may also be influenced by the priority in planning for cars. Planners and designers are much more aware of the needs for comfort and efficiency of car drivers than of the needs of two-wheeler riders and pedestrians.

When fewer people choose to walk or cycle, planning for them is given less priority and problems are not resolved. Moreover, differences in exposure lead to differences in the risk per kilometre. A low proportion of a mode in traffic affects expectations and results in a worse anticipation by other road users.

Lack of communication between road users is a basic element of accident-generating processes, as drivers may be surprised by unexpected actions or may misunderstand each other's intentions. Communication is made difficult when speeds are high but also when the physical environment is not designed to help drivers focus their attention on pedestrians, or when there are visibility problems.

Elderly people run a much higher risk of being killed or seriously injured in accidents because of the higher vulnerability of their bodies. Children and youngsters have a much higher risk of being involved in accidents because of their lack of skills and their inexperience. Moreover, young people have a lifestyle which exposes them to critical traffic situations: they frequently drive at night, in the weekend and in the company of friends, after disco and pub visits.

Sensation-seeking applies to about 30% of the car-driving population. Young drivers tend to be less concerned with their own speed as a potential risk factor. In combination with a lower seat belt use, they put themselves more at risk. Most riders of motorised two-wheelers enjoy the direct sensation of speed (offered by the absence of a bodywork) and the control of the vehicle with the whole body.

8.3. **Mobility analysis**

The choice of walking and cycling as a means of transport probably depends on a large number of factors. In particular, a traffic and physical environment which is not user-friendly and strong feelings of a lack of safety may act as deterrents, although this phenomenon has not been quantified. This relation is especially pronounced for the more vulnerable pedestrians: children walk less and less and are more often ferried by a parent by car. This is without doubt for fear of accidents, perhaps for fear of other dangers.

Concerning cycling, the situation varies considerably in Europe. While in some cities, such as Madrid, the level of bicycle use is extremely low, in others, such as Groningen in the Netherlands, about 57% of all trips are made by bicycle. In France and Great Britain, bicycle ownership is high but the usage is rather low. Very different policies exist at city, region and country level, and the systems of government and their respective powers will also have an impact on bicycle use. Cultural backgrounds and the legal and fiscal situation also have an impact. Climate and terrain do have an impact, but a smaller one than might be estimated.

The usage of motorised two-wheelers is steadily increasing. Between 1980 and 1990, the total number of motorised two-wheelers in use first fell, then rose, and continued to do so in the nineties. The fall was due to a fall in the number of mopeds. During the 1950s, motorised two-wheelers were used predominantly for functional purposes. With increasing availability of cars, however, the emphasis shifted more to leisure time use. In the last ten years, because of the problems of urban traffic, motorised two-wheelers are being used increasingly for functional purposes in addition to leisure purposes.

To consider walking and cycling as a means of transport requires a change of thinking at the political level. If the safety and mobility of all groups is to be enhanced in an integrated way, a better balance in mobility and safety for all modes of transport has to be created. Modes to be promoted will be subject to higher quality requirements and to fewer restrictions. Political interventions are needed. Moreover, road users ask for this. Several studies (e.g. the SARTRE survey, 1998) show that more people ask for a higher planning priority for walking and cycling than for car driving. However, consultation with citizens, road users and interest groups such as shop-keepers, seems to be an important condition to select the measures that fit the best those with different needs and interests.

As a consequence, the criteria used in traffic and transport planning will have to be reviewed. Different criteria must be applied for flow, accessibility, capacity and the like for the different modes and maybe also for the different types of journeys.

8.4. Measures to be promoted

On the basis of cost-benefit analysis, the following types of measures are recommended:

- Measures that *reduce driving speed*, especially in urban areas, will improve safety, and sometimes mobility, for pedestrians and cyclists, but more kinds of benefits have to be included in the analysis.
- The benefits of *facilities for pedestrians and cyclists* exceed costs by a wide margin.
- Measures that *improve conspicuity and visibility* are cost beneficial.
- The implementation of measures regarding *injury protection* underrun guard rails and helmet wearing for motorised two-wheelers.
- Graduated licensing and *driver's licence on probation*, *including a lower BAC limit of 0.01%,* are promising measures for inexperienced drivers.

Although single measures may be effective, isolated safety measures of one single type do not, in general, go very far in reducing safety and mobility problems. It is considered more advisable to go, as far as possible, for balanced and comprehensive solutions, rather than to seek a one-to-one correspondence between problems and countermeasures.

The results of the cost-benefit analysis can be combined with the recom-mended measures of the reports on pedestrians, cyclists, motorised two-wheelers and young car drivers. Doing this, we must be aware of the fact that we could only include isolated measures in the cost-benefit analysis. Thus we conclude that the following 10 measures are the most important according to the PROMISING project:

1. A separate network of direct routes for pedestrians and a separate network of direct routes for cyclists.

2. Transport alternatives for young drivers like disco buses.

3. A categorisation of roads to separate flow traffic from distribution traffic and access traffic.

4. Area-wide speed reduction apart from roads with a flow function for motorised traffic.

5. Implementation (and development) of infrastructure design standards for pedestrians, cyclists and motorised two-wheelers.

6. Right-of-way rules and regulations for cyclists and pedestrians in urban areas and technical measures that support right-of-way and stimulates perception and anticipation.

7. Review of traffic rules to consider privileges for motorised two-wheelers in relation to car drivers.

8. A graduated or intermediate licensing system for young car drivers and motorised two-wheelers.

9. Education that focuses on a considerable and respectful attitude to other road users.

10 Injury protection by design of cars and heavy vehicles.

8.5. Better planning and more structural approach

The way forward may aim at a transport policy decreasing the need to use a car, giving priority to walking and cycling for short trips, and an explicit policy regarding the use of motorised two-wheelers.

The safety approach has to be interrelated. Main elements are:
- segregation of motorised traffic with a flow or distribution function from non-motorised transport,
- creating a network of main traffic routes for pedestrians and cyclists,
- a fair balance between motorised and non-motorised traffic for right-of-way facilities at crossings,
- limiting the speed of motorised traffic in case it shares the road with non-motorised traffic.

The risks of the vulnerable groups will decrease both by safety measures and by the transport policy. But measures require a framework that takes different needs into account. The rapid growth of mobility, along with the impact of traffic on liveability and the environment, necessitates long-term planning.

Long-term planning is also needed if real progress is to be made in the field of road safety. New concepts have been developed that stop defining road fatalities as a negative, albeit largely accepted, side effect of the road transport system. The probability of accidents can be reduced drastically by means of the infrastructural design. And where accidents still occur, the process which determines the severity of these accidents should be influenced in such a manner that the possibility of serious injury is virtually eliminated. The Dutch sustainably safe traffic system and the Swedish zero vision concept are examples of such a concept.

The Dutch sustainably safe system has:

- a structure that is adapted to the limitations of human capacity through proper design, and in which streets and roads have a neatly appointed function, as a result of which improper use is prevented,
- vehicles fitted with ways to simplify the driver's tasks and designed to protect the vulnerable human being as effectively as possible, and
- a road user who is adequately educated, informed and, where necessary, guided and restricted.

The road safety system can be combined with transport policies that consider walking and cycling as a mode of transport. This approach can be implemented gradually. Short-term measures do not have to wait but should be reviewed and put in the framework of the recommended long-term approach.

8.6. Key factors for implementation

Although a fundamental change is necessary, this does not mean that it will be impossible to obtain results in the short term in the field of improvement of the safety and mobility of vulnerable road users. Progress is being made already. Measures that fit in this approach will have to be given a more structured basis, and other elements will have to be combined.

Implementation of a good proportion of the safety measures applied in urban areas requires co-operation between local authorities and the national government or administration.

Target setting is a good way of establishing what has to be done to plan for the future. It makes clear what kind of resources we need to bring in, what kind of tools are needed for good planning, and it directs our activities to look for an effective and efficient approach.

A further common recommendation for all groups is to involve the road users or their representatives in the planning process. The analyses made clear that their needs have not been taken into account in the planning and the design of facilities. The best means for determining whether measures will work and whether they will provoke a good use of facilities and the right behaviour is involvement of the road users

Development of expertise and training is an important precondition for the development of effective policies, in both government and the private sector.

8.7. Is a non restrictive approach promising for safety reasons?

For walking and cycling, safety problems have a direct relation with the absence of a mobility policy. Recognition that walking and cycling are means of transport opens up a wide variety of measures with a high potential for safety improvement. The possibilities for promotion of walking and cycling by fulfilling requirements like comfort , direct access, priority and safety, shows there is no need to limit our perspective of walking and cycling to problem aspects.

Acknowledgement of walking and cycling as means of transport however, asks for a fair balance between the interests of different modes of transport, limiting the threat motorised vehicles impose to walking and cycling. Categorisation of roads and traffic calming provide a good framework for this.

The positive margins between benefits and costs for these kind of measures are also wide. Still more priority for walking and cycling finds support when other benefits are also taken into consideration, like health and a good city and residential climate for leisure, recreation and shopping. This is also the case when the disadvantages of motorised traffic like pollution, noise and space requirements are included. Thus, a safety policy for pedestrians and cyclists is most effective if it is combined with a mobility policy and therefore is non-restrictive in its nature.

For motorised two-wheelers and young drivers the situation is different. The risk when riding a motorised two-wheeler is high on average. Also sub-groups of young drivers have a very high risk.

A non-restrictive policy for motorised two-wheelers can only decrease safety problems but cannot solve them sufficiently. In any case, it is important that their special needs are better taken into consideration, e.g. in the design of road infrastructure.

For young drivers, a non-restrictive policy means that transport alternatives be developed to cater their mobility needs.

A restrictive policy for both motorised two-wheelers and young drivers is needed, which means age and full licensing limitations. Besides this, speed control and injury protection measures are necessary. Thus, for these target groups, a safety policy can impossibly be non-restrictive.

From the conclusions of the PROMISING project, two recommendations for further research seem to be most important.

1. The actual absence of explicit policies for different modes of transport means that criteria have to be developed to cater their needs and to review current criteria for traffic flow, right-of-way regulations and so on. Several countries already have developed manuals for a better planning of cycling, outlining basic principles and presenting design alternatives. Much can be learned from the expertise and experiences to develop solutions adapted to other national and local situations with a different transport and traffic history.

2. Cost-benefit analyses may support the selection of priority measures. But a more solid basis is necessary to take into account the different kind of benefits of traffic and transport policy alternatives. Current data for cost-benefit analyses are biased by the amount and speed of motorised traffic.

The measures presented in this report are sufficiently PROMISING for safety improvement to justify adoption of the approach for a better balance in planning and investments for all modes of transport.

References

ADONIS (1998). *Analysis and Development Of New insight Into Substitution of short car trips by cycling and walking*. Danish Road Directorate, Copenhagen, Denmark.

BASt (1997). *Vergleich des Verkehrsordnungsrechts in Europa; Literaturübersicht unter Berücksightigung der kommunalen Verkehrsüberwachung*; von Dieter Ellinghaus, Klaus Seidenstecher und Jürgen Steinbrecher, IFAPLAN, Köln; Bericht von BASt, Mensch und Sicherheit, Heft M 69, Bergisch Gladbach, Germany. [In German].

Cauzard, J.-P. & Wittink, R.D. (eds.) (1998). *The attitude and behaviour of European car drivers to road safety; Project on Social Attitudes to Road Traffic Risk in Europe SARTRE 2. Part 1: report on principal results.* SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

DUMAS (1998) *Developing Urban Management And Safety; Workpackage 6: Safety for pedestrians and two-wheelers.* Danish Road Directorate, Copenhagen, Denmark.

Dutch Ministry of Transport (1998). *Final report Masterplan Bike: summary, evaluation and an overview of projects in the framework of Masterplan Bike 1990-1997.* Dutch Ministry of Transport, Public Works and Water Management, The Hague, the Netherlands.

EC DGXI (1999). *Cycling: the way ahead for towns and cities.* Directorate General XI, European Commission, Brussels, Belgium.

Elvik, R. (1993). *Økonomisk verdsetting av velferdstap ved trafikkulykker. Dokumentasjonsrapport.* TØI-report 203. Institute of Transport Economics TØI, Oslo, Norway. [In Norwegian].

Elvik, R. (1996). A *meta-analysis of studies concerning the safety effects of daytime running lights on cars*. Accident Analysis and Prevention, Vol. 28, pp. 685-694.

Elvik, R., Mysen, A.B. & Vaa, T. (1997). *Trafikksikkerhetshåndbok. Oversikt over virkninger, kostnader og offentlige ansvarsforhold for 124 trafikksikkerhetstiltak.* Third edition. Institute of Transport Economics TØI, Oslo, Norway. [In Norwegian].

FERSI (1996). *Road safety research and policy in Europe: mission paper of Forum of European Road Safety Research Institutes FERSI.* Forum of European Road Safety Research Institutes, Leidschendam, the Netherlands.

OECD (1997). *Safety of vulnerable road users*. Organization for Economic Co-operation and Development, Paris, France.

PROMISING (2001a). *Measures for pedestrian safety and mobility problems*. Final report of workpackage 1. NTUA National Technical University of Athens, Greece.

PROMISING (2001b). *Measures to promote cyclist safety and mobility*. Final report of workpackage 2. VTT Technical Research Centre of Finland.

PROMISING (2001c). *Integration of needs of moped and motorcycle riders into safety measures.* Final report of workpackage 3. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

PROMISING (2001d). *Safety of young car drivers in relation to their mobility*. Final report of workpackage 4. BASt Bundesanstalt für Straßenwesen, Germany.

PROMISING (2001e). *Cost-benefit analysis of measures for vulnerable road users.* Final report of workpackage 5. Contribution of TRL Transport Research Laboratory, United Kingdom.

PROMISING (2001f). *National and international forums to discuss the approach and the results of PROMISING*. Final report of workpackage 7. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Tight, M.R. & Carsten, O.M.J. (1989). *Problems for vulnerable road users in Great Britain, the Netherlands and Sweden. Final report for workpackage 2 of Drive Project V1031: An intelligent traffic system for vulnerable road users.* Institute for Transport Studies, University of Leeds, United Kingdom.

WALCYNG (1998). *How to enhance WALking and CYcliNG instead of shorter car trips and to make these modes safer.* Department of Traffic Planning and Engineering, Lund University, Sweden, and FACTUM Chaloupka, Praschl & Risser OHG, Vienna, Austria.

List of publications resulting form the project

Final report for publication
Promotion of mobility and safety of vulnerable road users. Final report of the European research project PROMISING.
SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Deliverable 1
Measures for pedestrian safety and mobility problems. Final report of workpackage 1.
NTUA National Technical University of Athens, Greece.

Deliverable 2
Measures to promote cyclist safety and mobility. Final report of workpackage 2.
VTT Technical Research Centre of Finland, Espoo, Finland.

Deliverable 3
Integration of needs of moped and motorcycle riders into safety measures. Final report of workpackage 3.
SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Deliverable 4
Safety of young car drivers in relation to their mobility. Final report of workpackage 4.
BASt Bundesanstalt für Straßenwesen, Bergisch-Gladbach, Germany.

Deliverable 5
Cost-benefit analysis of measures for vulnerable road users.. Final report of workpackage 5.
TRL Transport Research Laboratory, Crowthorne, United Kingdom.

Deliverable 6
National and international forums to discuss the approach and the results of PROMISING. Final report of workpackage 7.
SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Leaflet
Integrated planning for mobility and safety is promising. Leaflet on the European research project PROMISING.
SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.