Deliverable D 2

Measures to promote cyclist safety and mobility

Public

P R O M I S I N G

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

Workpackage 2

Contribution of:
VTT, Technical Research Centre of Finland

July 2001

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

Deliverable D 2

Measures to promote cyclist safety and mobility

Public

P R O M I S I N G

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

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

Co-ordinator Workpackage 2:
VTT - Technical Research Centre of Finland

Partners Workpackage 2:
ENFB - Echte Nederlandse Fietsersbond, the Netherlands
I-ce - Interface for Cycling Expertise, the Netherlands / United Kingdom
INRETS - Institut National de Recherche sur les Transports et leur Sécurité, France
SNRA - Swedish National Road Administration, Sweden
SWOV - SWOV Institute for Road Safety Research, the Netherlands
TRL - Transport Research Laboratory, United Kingdom

July 2001

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

Notice to the reader

This volume is one of the six deliverables 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.

The 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.

SUMMARY

This report presents the main principles for a policy to implement non-restrictive safety measures for cyclists. ‘Non-restrictive’ means that an efficient and comfortable mobility of cycling is taken into account when safety measures are designed. The approach for such a policy is illustrated by data and by examples of strategies and measures.

From a decline to an increase

During the 1950s and 60’s, cycle use declined from its historically high levels, as access to private motor vehicles became more affordable to many. This change seemed to represent progress. The oil crisis in the mid 1970’s interrupted this progression, and forced a rethink of how mobility, especially in urban areas, might be managed. Now, some 25 years after the oil crisis, most people recognise that unrestrained car use has serious implications. Alternative modes of transport need to be given priority and their use encouraged. The quality of cities has been threatened by the space taken away by motorised transport, and the danger, noise and pollution it produces. Alternatives are needed to serve the cultural, social and economic function of urban areas. Cycling is an alternative for short car trips that transport people in an inefficient way from door to door and, moreover, it may become an important feeder for public transport. In that respect many cities, regions, and countries have developed pro-cycling policies and many have had success.

Challenges, opportunities, and barriers

When comparing countries, we should recognise how factors that determine bicycle use, work. An overview of actual cycling in Europe shows huge differences. In many countries one can find cities where the share of cycling in all trips made is about 20 to 30%. But at a national level, such a share is only present in the Netherlands and Denmark.
Calculations about the potential for a modal shift from car to cycling, have shown e.g. in Germany that at least 30% of car trips in urban areas could be replaced by cycling trips. Road safety withholds many people from using a bicycle.

However, there remain barriers to increased cycle use, not least the safety issue. Surveys show that people are not in principle opposed to cycling. They ask for a better planning, and complain about safety and other problems. Their mobility and safety needs are not taken into account. If cycle use is to be increased and maintained, there has to be an answer to the concerns, both real and perceived, of cycle use and its safety. This conclusion underlines the need for a non-restrictive safety approach.

Road safety standards depend on facilities and the share of cycling in transport. Countries with a high share of cycling have a risk of a fatal accident per km cycling that is 3 or 4 times lower than countries with a low share. There are many examples of cities that invested in facilities for cyclists, increased cycle use, and at the same decreased the number of fatal accidents.
Apart from this, cycling has a great impact on the prevention of diseases because it contributes to the fitness of people. This impact on the health standards is many times more important than the road safety toll.

Main principles

To describe the main principles for a policy to promote safe cycling, this report starts with criteria that take the needs of cycling seriously.
Then a new road safety approach for design and infrastructure is described, based on a hierarchical division of roads and streets. For urban areas, this is elaborated in a division of five road categories each with a different traffic function and a design and behavioural requirements adapted to this function. This has been combined with planning and design principles for walking and cycling. Designs for crossings are also presented to accommodate both mobility and safety needs. A key element for these solutions is improved interaction between motorized and non motorized transport modes.
Recommendations for traffic regulations are added to this, to enhance the protection of cyclists and their rights for an efficient and comfortable use of the road.
In addition to this, technical requirements for the bicycle and for other vehicles that are important for the safety of cycling, are reviewed.
Further, main principles for transport and road safety education and driver instruction are presented. Only when the characteristics of man, the road and the vehicle are adjusted to each other, can the transport and traffic system work as planned.

The report is completed with main principles for an implementation strategy, taking into account national and local situations, and factors of influence.

CONTENTS

FOREWORD **5**

1. INTRODUCTION **7**

2. PRESENT SITUATION AND CHALLENGES **9**
- 2.1. Introduction 9
- 2.2. Mobility 10
- 2.3. Road safety 11
- 2.4. Health and accessibility 14
- 2.5. Conclusions 16

3. CRITERIA TO ACCOMMODATE TO THE NEEDS OF CYCLISTS **17**
- 3.1. Heading for a new balance between modes of transport 17
- 3.2. Requirements for cyclists 18
- 3.3. Consequences for planning 19
- 3.4. Road safety concepts 21

4. A SAFE NON-RESTRICTIVE PEDESTRIAN AND CYCLE NETWORK **22**
- 4.1. The need for measures 22
- 4.2. New concepts for safety and other needs of cyclists 23
- 4.3. Traffic Network and Street Design - A new and non-restrictive approach for European cities 25
- 4.4. Context 34

5. REGULATIONS **35**
- 5.1. Introduction 35
- 5.2. Main principles 35
- 5.3. Review of current situation 36
- 5.4. Implementation 38

6. VEHICLE REQUIREMENTS **39**
- 6.1. Bicycle equipment 39
- 6.2. Helmets 40
- 6.3. Requirements for other vehicles 41

7. EDUCATION **42**
7.1. General principles 42
7.2. School education 43
7.3. Driver instruction 43
7.4. Implementation 44
7.5. Examples 45

8. IMPLEMENTATION **46**
8.1. Aim for connections and network 46
8.2. Involve the road users 47
8.3. Involve the community 47
8.4. Set realistic targets 47
8.5. Create a good bicycle climate 48
8.6. Create good governance and structures 48
8.7. Train professionals 49
8.8. Monitor success and failures 50
8.9. A structure for implementation conditions 50
8.10. Summary 51

REFERENCES **53**

APPENDIX Non-restrictive measures promoting safety and mobility 57

FOREWORD

The work for this report was executed by a group of experts from five countries. Leader of this group was Lars Leden (VTT, Finland), with assistance of Jukka Räsänen (VTT, Finland).

The following persons contributed to the various activities:
- Problem analysis: Arantxa Julien (INRETS, France).
- Criteria for cyclists' needs: Tom Godefrooij (Fietsersbond enfb, the Netherlands).
- Design of street infrastructure: Per Wramborg (SNRA, Sweden).
- Crossing facilities: Lars Leden (VTT, Finland).
- Regulations, education and cycle requirements: Roelof Wittink (SWOV, the Netherlands).
- Injury protection: Pat Wells (TRL, Great Britain).
- Implementation of measures: Oliver Hatch (I-ce, the Netherlands)
- Final edition: Roelof Wittink (SWOV, the Netherlands).

1. INTRODUCTION

The Directorate General for Transport, DG VII of EU, asked in 1997 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 co-ordinated by the Dutch Road Safety Research Institute SWOV put forward a project plan. To choose and make use of the acronym PROMISING, the subject was rephrased as:
The 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 at the 1st January 1998.
The potential for problem reduction was specified for four categories of road users: pedestrians, cyclists, motorized two-wheelers and young car drivers.

This report presents the results of Workpackage 2 (WP2) concerning cycling, that developed main principles for a policy to implement non-restrictive safety measures for cyclists, illustrated by data and good examples.

The work in WP2 was structured in the following way:

Problem analysis
Problems experienced by non-motorized two-wheelers are both accidents and mobility problems, related to their own characteristics as road users and to their environment, which is not always properly adapted to fit these.

Criteria for cyclists' needs
Main requirements for a bicycle-friendly infrastructure have been presented with implications for planning and design.

A safe non-restrictive pedestrian and cycle network
A vision of a non-restrictive safe street infrastructure and cross road design was developed, based on the Dutch 'Sustainable Road Safety System' and the Swedish 'Vision Zero'.

Regulations and education
Regulations are presented because of their impact on the restrictiveness of mobility of the different road user groups. Regulations also have a function to guide technical and non-technical measures.
Education is considered as a condition for safe behaviour, apart from other measures, and as a condition to support the implementation of other measures, to help people making a good use of the infrastructure and the vehicle.

Vehicle requirements
The contribution to the incidence of cycle accidents with regard to technical defects of the bicycle has been assessed and potential measures for bicycles presented to reduce casualties. Requirements for other vehicles, such as soft noses of cars and side impact protection for trucks, were also assessed.

Implementation of measures
The aims of a policy framework for the bicycle at an international, national, regional, and local level are described. They are illustrated by some ‘best practises’.

2. PRESENT SITUATION AND CHALLENGES

2.1. Introduction

To develop measures and policies to enhance the safety and mobility of cycling, first the present situation has been described. This chapter provides data about mobility, safety, and the benefits of cycling.

The situation in Europe is quite diverse. While some cities have almost immeasurably small if non-existent levels of cycle use such as Madrid, others like the city of Groningen in the Netherlands have about 57% of all trips made by cycle (Dutch Ministry of Transport, 1995). 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 cycle use. Cultural backgrounds as well as 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 of over 100,000, cycle usage is 35% of all trips (Myllylä, 1995). It is just over 160 kms south of the Arctic circle. In Padova and Ferrara in the Po valley of Italy, cycle usage is also at this level, but it is distinctly hot there for many months of the year, and cold and damp in the winter. Basel in Switzerland is scarcely flat, but has 17% cycle use and only 27% car use. Climate and terrain obviously are a factor in determining the level of cycle use, but its importance is over-stressed.

The cycle-friendly quality of European countries can be categorised into five types. They are mainly based on a north - south divide, with the north being more advanced, but these are necessarily generalisations at a national level, which can mask significant regional differences.

I. The Netherlands, Denmark, Switzerland, and parts of Germany have national policies that favour cycling. They also have a strong recognition that cycling is a valuable part of the transport mix, and that it needs to be provided for and encouraged. Cycling is widely used and a part of the cultural background.

II. In the UK, Sweden, Norway, Austria, Finland, Northern Italy, and parts of Belgium, the level of cycling is not that great, but as far as policy is concerned, the arguments have largely been accepted about why cycling should be supported.

III. In France, other parts of Italy, Spain, Ireland, and parts of Germany and Belgium there is some recognition of the bicycle, but overall its status is low and it is mainly seen just as 'peasants' transport' or a leisure activity. However, cycle use in France is very varied; Strasbourg has 15% of all vehicle trips by bicycle, and more than 100 kms of cycle routes exist in both Bordeaux and Rennes (Club des Villes Cyclables, 1997).

IV. In Greece and Portugal, the status of cycling is very low, and little is being done officially. There is leisure cycle use and groups that represent them, but little or no general recognition of the part that cycling can play in transport policies. Consequently users and campaigners have a hard task ahead of them.

V. Central European countries have to be placed in a special category of their own, given that their situation is very different from other European countries. Previously, owning a private car was rare, and the bicycle, with public transport, played a predominant role. Now many want a car, seeing it as a status symbol. There has been a fall in cycle use. However, views are evolving and some ministers in central countries are now pro-bike in their pronouncements.

The following sections present:

- facts about mobility, such as actual level of cycling, the relation between ownership and usage of bicycles and the potential for cycling,
- data about accidents, including the relation between mobility patterns and risk,
- facts about cycling in relation to important aspects of life and society, within the framework of:
    - health, for which safety and personal fitness are important impacts of cycling
    - the environment, for which energy savings and pollution are important
    - traffic and transport, for which safety and congestion are important.

The purpose is to give a picture of the potential contribution of cycling to traffic, transport, and other relevant policies.

2.2. Mobility

2.2.1. Stock and use

Mobility data informs us about the actual travel behaviour and the modal split.
The Dutch have the largest figure for bicycle use per inhabitant in Europe: more than 1,000 cycle km per inhabitant per year and a modal share of 28%. With 15 million people, they own 16 million bikes and make 16 million cycle trips per day in the mean. Denmark follows with 960 cycle km per inhabitant and a share of 18% and Sweden comes third with 300 cycle km and a share of 15%. (ECF, 1997; Dutch Ministry of Transport, 1995).
It is interesting to notice that in countries where cycling as a mode of transport is not very common (southern Europe), there are no statistics easily available. However, in these countries, there can be large differences from one region to another (e.g. some Italian cities like Ferrara where cycling accounts for about one third of the trips; EC DGXI, 1999).
Bicycle ownership is not linked to bicycle use. An increase in bicycle stock, like in France or United Kingdom, did not lead to an increase in bicycle use (ECF, 1997; Hansen, 1995; Carré, 1998).

2.2.2. Potential use

Brög and Erl (1994) have studied the potential for modal shift from car to cycling in German cities. He has shown that at least 30% of car trips in urban areas could be replaced by cycling trips.
Just by replacing a quarter of short car trips by cycle trips, the cycle share would be doubled in Finland and Norway, and multiplied by about 3 in Great-Britain, and by 4 in France. The reduction in the number of car trips would be high.

The key to promoting cycling use, may be to change the habits of decision makers, planners, and citizens. They are still strongly inclined to only satisfy the mobility demands of motorised traffic. They should realise that cyclists and pedestrians are just as much road users as are car and lorry drivers. Nowadays they often forget about the potential contribution of alternatives like cycling.
The lack of facilities make cycling unattractive, and in many cases dangerous. Decision-makers, planners, and citizens reinforce each other in this way. There are not many cyclists because of the lack of facilities and there is no investment in cycle facilities because there are few cyclists.

E.g. in France, using a bicycle for leisure and sport is popular, but not for utilitarian purposes.

Brög has also shown that the wishes of road users differ very much from that of politicians. They preferred a bicycle policy far more than politicians did.
Even car drivers give priority to planning for the bicycle (and public transport and walking). In the SARTRE survey (Cauzard and Wittink, 1998), car drivers in 19 European countries were asked how much consideration for future planning should be given to the different modes of transport. The percentages answering “very much” are presented in *Table 1* for 13 EU-members together and for a selection of individual countries.

Table 1. *Percentage of car drivers in Europe and some individual countries, answering that “very much” consideration in future planning should be given to the different modes of transport.*

Mode of transport	EU	FIN	S	UK	IRL	NL	B	F	D	A	H	Slov	E	I
Public transport	55	39	56	66	71	58	45	43	52	52	64	32	38	71
Pedestrians	51	52	50	59	65	48	63	60	42	38	65	30	47	46
Cyclists	50	57	51	51	66	58	64	63	46	40	64	34	50	39
Lorries	42	32	31	41	61	42	38	47	40	27	54	30	32	47
Cars	37	38	31	39	65	34	42	38	32	25	59	27	27	43
Motorcyclists	37	20	24	35	48	28	39	51	34	24	48	21	41	31

2.3. Road safety

Road safety problems may be an important deterrent for cycling. This section presents data that give a perspective of the risk of cycling.

To show the road safety consequences in the case that car trips are replaced by bicycle trips, the accident risks of car use and bicycle use in these cases have to be compared. It is however difficult to compare accident statistics with mobility data. The best way would be to compare accidents and injuries per time spent or per trip. Analyses of this kind are not available yet.
A first indication is given when we compare all fatal injuries with all kilometres made. By doing this, it turns out that in the Netherlands, for people from 18 to 30 years old the risk of cycling is lower than of car driving.
But we have to compare risk in the car on trips that can be replaced by a bicycle. An estimation to compare all fatal injuries with all kilometres made - except the very safe kilometres on highways that cannot be replaced - show that in the Netherlands for people up to 40 years old the risk of cycling is lower than for car driving.
But we should not only take into account the risk for a person itself. We have also to take into account the risk of a mode of transport for other road users. If we include this, road safety in the Netherlands will be better off when people up to 50 years old choose the bicycle instead of the car as much as they can (DUMAS, 1998; EU DGXI, 1999).

We also have to take into account that the Dutch safety record for cyclists is the best in Europe. A comparison of the risk for a fatal injury per kilometre cycling between several European countries has been done in the EU project WALCYNG (1998). The risk of a cyclist for a fatal accident on the road is per kilometre in the UK about 4 times higher than in the Netherlands, in Finland 3 times higher.

The best explanation for this is the experiences of Dutch road users with cycling traffic and the great amount of facilities of high standards. Moreover, when road users are not used to meet a certain mode of transport, they may not perceive and anticipate adequately. As is stated in WALCYNG: “Rare events are dangerous”.

The data shows that cycling is not a safety problem in itself. When cycling is promoted by facilities, it may become safer than car driving. Of course, the quality of facilities will influence the safety level significantly.
A good example of showing that risk decreases when exposure increases, is the city of Graz (Austria). There, cycling measures have been introduced alongside area wide "Tempo-30" zones. The number of cycle trips have increased by 50% between 1984 and 1995, and the number of cycling casualties have fallen by 20% over this period (Edwards, 1998).

2.3.1. Accident statistics

One way to evaluate the road safety problems of cyclists, is to analyse accidents statistics. However this kind of analysis can only provide limited information. One reason is that police reports concentrate on the liability and traffic offences. Another is that cycling accidents are often under-reported by the police, in particular if there are only slight injuries. For example, in Denmark, only 10% of the accidents with slight personal injuries and 50% of the serious accidents involving cyclists are reported to the police (OECD, 1997).

The following data about location where, and circumstances in which, accidents with cyclists took place, comes from the OECD (OECD, 1997).

<u>Most accidents occur in urban areas</u>
About 3/4 of all reported accidents involving cyclists take place in urban areas. However, only between 1/2 and 2/3 of the fatalities occur in urban areas: the accident severity is higher in rural areas, due to the higher vehicle speed in such areas.

<u>Most accidents occur at junctions</u>
Bicycle accidents mostly occur at junctions, but tend to be more serious on stretches. The vehicles’ higher speed there is probably partly responsible. It is generally found that the accidents involving cyclists are more likely to occur on minor roads (where cycling is more frequent) and at intersections where a minor road connects to an arterial road. Most reported severe and fatal accidents involving cyclists have been found to occur, either at road junctions, or at crossings between a street and a cycle track.

<u>Accident time of the day</u>
Although the majority of accidents involving cyclists occur during daytime, the proportion of these accidents resulting in fatalities and severe injuries seems to be relatively high during night-time (20% in the Nordic countries). The night-time accidents are more often fatal for the cyclist (in France, 1/3 of cyclist were killed at night). In the Netherlands, about 20% of registered injured cyclists had an accident during (nearly) darkness. In 1996, it turned out that only 55% of cyclists had their lights on during those circumstances.

<u>The cyclist's crash opponent</u>
By far most of the reported injuries of cyclists are the consequence of a collision with a motorised vehicle.
According to police records, in 51% of all fatal accidents with cyclists in 1995 – 1998 in the Netherlands, a car was involved, and in 31% a lorry, bus, or van were involved. A motorised

two-wheeler was involved in 4% of the fatal accidents, another cyclist in 2%, and other vehicles in 5%. In 5% of the fatal accidents no other vehicle was involved.
Regarding slight injuries, the share of heavy vehicles is much lower, only 9%. The car has a share of 56%, motorised two-wheelers 13%, cyclists 10%, and 8% occurred when no other vehicles were involved (BIS-SWOV, 1999).
Single accidents however are often not reported to the police, but they appear in hospital statistics.

Accidents with lorries occur almost exclusively in urban areas, and mostly at junctions. In Great Britain, lorries account for 5% of the traffic on major roads in built-up areas. They are involved in accidents accounting for only 2.5% of cyclist casualties. However, they are involved in 20% of the accidents that result in the death of a cyclist. In 1995, 6% of cyclists involved in a collision with a lorry died, compared with 0.5% of those involved in a collision with a car. About three-quarters of these fatal accidents occurred when a lorry turned left (left-hand traffic in UK) across the path of a cycle, overtook a cycle, or where both the cycle and lorry were turning left. These accidents often occur where a lorry driver does not see the cyclist approaching (DoE, 1997).

If cyclists do not have proper facilities of their own, and share the use of pavements - in some countries bicycle tracks are painted on sidewalks - a lot of bicycle/pedestrian accidents may take place (WALCYNG, 1998; Pibault and Bilman, 1996).

<u>The cyclists' age and sex</u>
Elderly and young cyclists have in general a higher risk. Children lack capabilities and experience, and elderly people are more vulnerable when they collide. They need more protection. Moreover, they perform cycling trips for different purposes (shopping, school, and leisure). A differentiated treatment of their safety problems is necessary.

2.3.3. Accident factors

The following conclusions about contributing factors are presented by OECD 1997, if no other reference is indicated.

<u>Speeding</u>
Drivers' speeding is a major factor in cyclist accidents. The severity of the impact is correlated with the speed. The speed factor can be understood in two ways: speed may be in excess of the local speed limit, or speed may be too high with respect to local traffic and environmental conditions, thus not leaving enough time for drivers to process information or to react to a possible incident with a vulnerable road user.

<u>Manoeuvres, anticipation, and compliance to right-of-way</u>
An in-depth analysis of accidents involving cyclists in France in 1991-92 has shown that in half of the collisions, the cyclist keeps its trajectory. 38% of the collisions are due to a changing of direction or overtaking from a car driver. In those cases, the car driver is responsible for 70% (Carré, 1995).
Car drivers are not always aware that they expose other drivers to risk, e.g. in parking on cycle lanes. Cyclists are then obliged to leave the lane to overtake the illegally parked car, and then can be knocked over by a vehicle approaching from behind. Insufficient information intake by young and elderly cyclists has been found to be a frequent factor in cyclist accidents.

Cyclists are also often found in accidents not to comply with the traffic regulations. They may have blocked the right-of-way, either by ignoring the priority system, or by stopping in the wrong place, or by performing sudden manoeuvres, or by cutting in front of other vehicles. This may be particularly true for both young and elderly. Crossing a junction when the traffic light is red may also be for cyclists a not unimportant accident factor

Cyclists in general display inadequate scanning behaviour when crossing. Cyclists have been found to take insufficient information particularly when they are travelling on a familiar route. Insufficient information intake is also the habit of car drivers, who frequently pay too little attention to cyclists in traffic.

Perception problems

Lack of visibility of cyclists is a factor in accidents. The fact that vulnerable road users are not always very well detected in the traffic plays a part, even in daytime. This is aggravated at dusk, dawn, and night, especially when public lighting is absent or weak. The most serious problem seems to be detection of cyclists by drivers approaching alongside or from behind. The limited physical visibility of cyclists (linked to their vehicle - car drivers are seeking for vehicles as big as theirs) is reinforced, at least in countries when cycling is not very common, by their lack of ‘social visibility’: car drivers do not see cyclists because they don't expect to see any.

Although cycle lanes have been found a good safety measure on road links - provided the width of the track is sufficient and measures have been taken to prevent accidents with vehicles parking - it appears that they tend to create safety problems at intersections. Particular attention has to be given to the design of cycle routes at these locations. Crossings between cycle tracks and streets do not always seem well understood by drivers, in particular, when environmental features do not clearly reflect the right-of-way, thus creating confusion among drivers and cyclists alike.

In general, safety facilities that are not used in the way they were intended to be, are more dangerous than useful. This is the case for facilities that have been designed without taking sufficient account of the needs and behavioural patterns of cyclists. Any facility requiring an effort and some time to be understood, and which is thought to be too much a constraint, won't be (correctly) used by cyclists.

Bicycle defects

The influence of technical defects of the cycle, the quality of the road surface, and the presence of protective devices (such as cycle seats and wheel spoke covers) has been analysed in the Netherlands. A technical cycle defect was cited as the principal cause of the accident by 7% of cyclists aged twelve years and older. In most cases, the condition of the brakes was poor (Schoon, 1996).

2.4. Health and accessibility

To consider the interests of cycling for society as a whole, more can be taken into account than the potential for its use and safety provisions.

Cycling contributes to health in different ways. An increase of cycling decreases the risk per trip. Moreover, by replacing car use, health problems are prevented as a consequence of pollution by motorised vehicles. Cycling also contributes to fitness in a way that may prevent diseases. Cycles consume less space than cars and also contribute to solve congestion problems. Some data are presented here as an illustration.

2.4.1. Fitness

The beneficial effects of bicycle on fitness in terms of prevention of cardiovascular risk have been assessed. In a study of 9,400 men in sedentary occupations (executive grade civil servants), 70% cycled at least an hour a week to work or at least 25 miles of other cycling a week. They were found to have an incidence of coronary heart disease of 2.5 per 1000 man years. This compares with 5.6 for non-cycling civil servants. Those cycling less kilometres had a rate of 4.5 (Morris, 1990, in Edwards, 1998).

This health aspect is 5 to 10 times more important than the safety aspect. ECF (1998) cites Hillman (1993), who calculated that years of life gained by cycling outweigh years of life lost in accidents by 20 to 1.

2.4.2. Pollution reduction

Motorised forms of transport cause pollution through noise and exhaust emissions. Cycling and walking do not produce such emissions. A Cyclists' Public Affairs Group study (cited by Edwards, 1998) had demonstrated that "modest increases in cycling could readily reduce transport sector emissions by 6% of the total", in Great Britain, while at Dutch levels there would be a 20% reduction.

Car traffic is moreover the major source of noise in towns. In France, since 1 January 1998 any renovation or construction of urban thoroughfares must include provision for cyclists. In addition, all conglomerations in France with more than 100,000 inhabitants had to adopt an urban mobility plan. The purpose of this is to reduce pollution-producing town traffic, by 1 January 1999. Monitoring of air quality and its impact on health will be carried out in the whole of France as from 1 January 2000 (EC DGXI, 1999).

Energy savings would also be an important benefit of increased level of cycling.

2.4.3. Space consumption

The space consumption of a cyclist was calculated to be only 8% of the space consumption of a car (UPI report Heidelberg 1989, cited by EC DGXI, 1999). An example is given in the following *Scheme 1*.

Scheme 1. *The estimated effects of a one-third reduction in the number of car trips from 44% to 30% of all trips in a city*.

- 30% less traffic jams,
- 25% reduction in pollution from motor vehicles (all types),
- 36% reduction in CO emissions,
- 37% reduction in CH by private cars only,
- 56% reduction in NO2 emission,
- 25% reduction in petrol consumption,
- 9% reduction in the number of people suffering from noise pollution,
- 42% reduction of the barrier effect of major highways.

The above figures are estimations in the 1980’s of the effects of a pro-bicycle policy in Graz, Austria (252,000 inhabitants; cited by EC DGXI, 1999).

2.5. Conclusions

The situation in Europe regarding bicycle use is quite diverse, as it is regarding cycling policies. There is a trend, however, to plan for the bicycle for utilitarian purposes as well as for leisure and sport.

The bicycle has a huge potential to replace short car trips.

Fatal accidents are strongly correlated to the speed of motorised vehicles, the weight and design of motor vehicles, design of cycle routes (especially cycle crossings), lack of anticipation of drivers and visibility of cyclists. A cycling policy that enhances safety and mobility, however, may have as a result that it is safer to use a bicycle for a short trip than a car. Other savings refer to health problems, pollution, and congestion.

3. CRITERIA TO ACCOMMODATE TO THE NEEDS OF CYCLISTS

Road safety policies with regards to vulnerable road users have been aiming at a safer behaviour of these groups in traffic. The understandable approach was (and often still is) that being vulnerable should result in being careful. The drawback of this approach is that the burden of the responsibility is on the shoulders of potential victims, rather than at the originators of the dangers on the road.
Developments in road safety policies since the seventies are more and more shifting from this "blame the victim" approach to an approach to minimise the physical dangers on the road. Traffic restraint and traffic calming are now common in most countries in Europe. Nevertheless even this new approach is not per se enhancing the freedom of movement of all vulnerable road user groups. Road safety measures still can be restrictive, especially for cyclists and pedestrians. Whereas it has become a general goal to promote these modes for a number of different reasons, it is worthwhile to set criteria for the (allowed) restrictiveness of such measures.

3.1. Heading for a new balance between modes of transport

Restrictiveness is a condition for all road users. In fact no human society can exist if people do not accept some restrictions. Freedom should always be limited where it starts to affect the freedom of others in a significant way. Basically, restrictions are acceptable to achieve a fair or proper balance of interests. What should be considered as 'fair' or 'proper', is in the end a political matter. Society as a whole (ideally and theoretically represented by its parliament and government) should make these choices. The working groups’ judgement of measures restrictiveness and effect on safety is given in the Appendix.

As far as the traffic and transport system is concerned, a general awareness is growing that the existing balance of interests between different categories of road users is neither fair, nor proper. The predominant position of motorised traffic is restricting the freedom of movement of other categories. Moreover, the massive use of motorised modes is generating a number of negative side effects on environment and the quality of life. And on top of that it seems that the transport system is becoming more and more inefficient, creating its own inaccessibility.

For all these reasons, there is a growing political awareness that a shift is required in the use of modes towards non-motorised transport and public transport. This requires a closer look at the present balance of interests, to make a judgement where this results in unfair or unwanted restrictions for these modes. The implication, however, will be that new restrictions will be imposed on the motorised modes. This is important for the question of how to make this concept of restrictiveness operational.

From this point of view, all criteria used in traffic and transport planning have to be reviewed. Criteria for flow, accessibility, capacity, et cetera have to be differentiated for the different modes, and maybe also for types of trip. Modes to be promoted will be subject to higher quality requirements and to lesser restrictions.

Restrictions in the traffic system can result in two distinct effects:
- Reduced mobility overall
- Wanted or unwanted modal shift.

Reduced mobility can be quantitative or qualitative:
- Quantitative: it might affect the number of kilometres travelled and / or the number of trips
- Qualitative: it might affect the level of social participation of (parts of) the population.

A qualitative approach is pleaded for: travelling is not a goal in itself, but a means to participate in social life (go to work, shopping, visiting friends, et cetera). To organise our society in a way, which requires a lower need for travelling large distances, the negative impact of transport on society can be diminished. As far as non-motorised modes are concerned, a transport and land use policy aiming at shorter travel distances might favour the use of these modes.

With regards to restrictions having potential effects on the modal shift, it is important how the measure affects the competitive position of cycling versus other modes. The restrictive effect of certain measures (if resulting in an unwanted modal shift) could be mitigated by similar restrictions on other (less favourable) modes. Thus the judgement of the restrictive nature of specific measures can be a relative judgement: it is only judged as being negatively restrictive if it favours a shift from walking and cycling towards motorised modes.

3.2. Requirements for cyclists

The most general description of restrictiveness with regards to cycling is “Any measure which might decrease the freedom of movement of cyclists or which might discourage cycle use”. There are a number of areas where there might be such a negative (i.e. restrictive) effect. A good basis for analysing the restricting factors of measures is the set of main requirements for bicycle-friendly infrastructure as it is formulated in the Dutch design manual ‘Sign up for the bike’ (CROW, 1993).
These main requirements are safety, coherence, directness, comfort, and attractiveness. Not complying with these requirements may result in a situation where cycling is not as attractive as is could be.

Safety:
For large parts of the population in Europe (the perception of) road safety problems is a key factor for not cycling. Improving the safety of cyclists on the road is therefore a precondition for cycle promotion. Whereas the scope of the PROMISING project is the promotion of safety, it will be the other four main requirements that provide the basis for restrictiveness assessment; i.e. our assessment will look at conflicts between the safety requirement and the other main requirements.

Coherence:
Criteria for coherence are 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 on the network level.

Directness:
Criteria are mean travel time, delays, and detours.
Any safety measure resulting in extended travel time, such as detours or delays are considered to be restrictive.

Comfort:
Criteria are smoothness of road surface, curving, gradients, number of stops between origin and destination, and complexity of rider's task. This criterion is relevant indeed, when it comes to judging the restrictiveness of road safety measures. Introducing narrow or sharp (uncomfortable to ride) curves, extra stops, and adding to the complexity of the rider's task, is considered to be restrictive.

Attractiveness:
Criteria are visual quality of the road, overview, variety of environment, and social safety. Road safety measures might result in less visual quality and more (perceived) social insecurity, and thus be restrictive.

Subjective character of judgement:
When judging restrictiveness, the experience or perception of cyclists is important and should be decisive. If cyclists don't like the measure, then the measure for these cyclists is in fact restrictive.

Of course, the perception of cyclists will not always be the same. Also, situations perceived as insecure are restrictive in themselves, and the quality gained has to be weighted against the quality lost on other criteria.

Perceived dangers constitute by themselves a restriction. More problems will be created if perception / experience of the road safety is not in line with the actual situation. The actual road situation should in any case evoke the necessary or appropriate alertness. Balance here is important. A negative experience will deter people from cycling (restrictive), a too positive perception might make people too careless and thus provoke unnecessary accidents.

If we take a closer look at the factors which at present restrict the use (and usability) of bicycles, it becomes clear that we need to look at very different levels of planning our transport.

3.3. Consequences for planning

Land use planning
The spatial distribution of activities is very much defining both the need for travel and the distances to be covered. Decisions on this level have a direct impact on the requirement of *directness*. It is very clear that a segregation of functions will generate more need for travelling. Space consumption, on the other hand, has a direct impact on distances between the functions. Long travel distances are restricting the usability of the bicycle. The present trends in bicycle use in the Netherlands may be illustrative: the bicycle promoting policies of the authorities have resulted in more bicycle use for trips up to 5 km. On the other hand the average trip length for all trips have increased. This increase of trip lengths results in a shift from bicycle to car. Thus the overall effect of the two trends is neutral. This underlines the need to develop a land use planning based on the principle of *'spatial proximity'*. Large-scale transport infrastructure in itself is an important cause of increasing space consumption and therefore a hindrance for 'spatial-proximity-oriented' land use planning.

Urban planning
Even if we have compact settlements with integrated functions, the urban structure can impose restrictions of bicycle use. At this level, the requirement of *coherence* of the bicycle network is at stake. But decisions on this level have also a direct impact on the number of encounters between cyclists and motorists, and in this way on the *safety* requirement. A clear recognisable bicycle route network should coincide with the urban elements (landmarks, etc.) which otherwise constitute people’s mental map of a city. Moreover, the traffic structure should not create barriers for non-motorised traffic. Often the coherence of the network of motorised traffic and the coherence of the bicycle route network are excluding each other. Present urban planning tradition is to start with defining a coherent traffic structure for motorised traffic. Bicycle provisions are seen as additional. This approach inevitably results in restrictions for smooth bicycle mobility. A reversal of the designing process is recommended: cycling and walking should be seen as main modes for urban transport. After all, a large share of urban trips is within cycling distances.

Public transportation is an important complement to these basic modes, especially for elderly citizens.
A good transport strategy should effect in complementary roles for cycling and public transport rather than in competition for these two modes. This requires an analysis of the strengths and weaknesses of these two modes and a careful assignment of investments. Public transport is very good and efficient when it comes to the transportation of large numbers of people on longer distances. It is however not very competitive on short distances and the accessibility of individual addresses is not very good either. Cycling has reserve characteristics: It is relatively fast on short distances and gives a very good access to individual addresses. On the other hand the bicycle is not a good option for long distances. To make the necessary investments to make both modes ‘perfect’ will be extremely expensive. The most cost-effective solution would therefore be to link both modes together into one coherent transport system. On the level of urban transport system the first priority should be given to cycling. Special attention should be given to investments to facilitate a smooth linkage between the two modes: bicycle-parking facilities at public transport terminals, bicycle transport facilities on trains and busses, etc.

In general it is essential that bicycles can be parked easily and safely. Like planning for car parking, a planning for bicycle parking is needed. This means bicycle stands at all the larger and more important destination points for cycling, as well as special locking devices or even the possibility of leaving bikes, either in a locker or under guarded supervision. This may be combined with bike repair and arrangements for bike rentals. When travelling shorter distances by train, commuter train or metro, possibilities to take the bicycle along is important.

Street design
Cyclists have the most direct experience of restrictions on the level of street design. This level of planning is relevant for all main requirements. Nowadays road design is often in line with the overall car-oriented structure of the traffic and transport system. Motorised traffic is considered to be 'normal', and all the rest is additional, catered for as long as space and money is available. This approach results in low quality bicycle facilities. Examples are the diversion of cyclists to the sidewalks, thus ignoring the vehicular characteristics of the bicycle; and the creation of too narrow bicycle tracks or lanes, ignoring the required profile or clearance. Such practices would be inconceivable with regards to motorised traffic.

But even if designers have a more positive attitude towards provisions for non-motorised transport, they often impose restrictions on these vulnerable modes 'for their own safety'. As pointed out before, such restrictions can only be avoided if it becomes acceptable to impose restrictions on motorised traffic.

A clear set of design requirements is very helpful to judge the quality of a specific design, but also to detect conflict of interests. In practice, it is often a problem that requirements for different modes are not expressed explicitly and clear. The design then is made on the basis of silently assumed values, which are mainly determined by tradition. Thus it is very difficult to make a judgement on conflicting interests, because the conflict is simply not perceived.

3.4. Road safety concepts

New approaches to road safety The 'Zero Vision' in Sweden (Wramborg, 1998) and the 'Sustainable Road Safety System' in the Netherlands (SWOV, 1992) are promising developments for all modes of transport. The starting point of both concepts is the restrictions on motorised traffic, which are necessary to achieve accepted targets for road safety. A strict hierarchy of urban road categories is the basis of this approach. But these concepts have never been developed to bring about a modal shift to non-motorised transport. Therefore, these concepts have to be combined with a straightforward optimising of the functionality of the street network for cycling. The main question in that respect is how to deal with main bicycle routes. Two questions arise:

1. Is it possible and desirable to give priority to main bicycle routes crossing routes for motorists? This problem can be avoided by grade-separated crossings at the main highways. But in many cases, the existing situation does not allow for such solutions. Moreover, grade separated crossings often result in undesirable detours and gradients for cyclists. In the case of existing main urban streets and collector streets, it will be an issue how to avoid taking away one restriction that might result in another restriction.

2. Is it acceptable to have priority bicycle routes within a residential area? The general thinking in both concepts is that within a residential area there will be no priority crossings. However, the network of main bicycle routes should be more fine meshed than the motorist network. The residential area, on the other hand, is defined in these concepts by the restraints imposed on motorists. To guarantee the unrestricted flow of cycle traffic, priority intersections on main bicycle routes are desirable.

In the next chapter a new approach of the road network is presented, combining new road safety concepts with the five requirements for cyclists.

4. A SAFE NON-RESTRICTIVE PEDESTRIAN AND CYCLE NETWORK

4.1. The need for measures

Chapter 2 showed that about 3/4 of all reported accidents involving cyclists take place in built-up areas, between 1/2 and 2/3 of the fatalities occur there. Most fatalities and serious injuries of bicyclists occur at intersections.

By far most fatalities and serious injuries of cyclists are the consequence of a collision with a motorised vehicle. The severity of the impact is strongly correlated with the speed.
Accidents with lorries occur almost exclusively in urban areas, and mostly at intersections.
In many European cities, both the speed of the motor vehicles is in excess of the local speed limit, and the speed limit is too high with respect to local conditions and safety aspects.
Speed is relevant both for the chance of an accident and for the severity of injuries. Lower speed leads to better interaction. A Finnish study underlined that drivers involved in a collision against a cyclist had omitted to give way in 2/3 of the cases.
So there is a need to provide a better system of speed limits in built-up areas and we must find counter-measures that more-or-less guarantee that the motor vehicles will not drive faster than the speed limit.

Lack of visibility of cyclists is aggravated at dusk, dawn, and night, especially when public lighting is absent or weak. The most serious problem seems to be detection of cyclists by drivers approaching alongside or from behind.

The right design of infrastructural facilities is another important factor to influence safety. Although cycle-tracks have been found a good safety measure on road links - provided the width of the cycle-track is sufficient and measures have been taken to prevent accidents with vehicles parking - it appears that they tend to create safety problems at intersections. Particular attention has to be given to the design of cyclist routes at these locations. Crossings between cycle-tracks and streets do not always seem well understood by drivers. In particular, when environmental features do not clearly reflect the right-of-way, they create confusion among drivers and cyclists alike.
So improved design for cyclists are needed at intersections. We must create solutions, which enables a feeling of mutual responsibility and enables good interaction between unprotected road users and drivers of motor vehicles.

Also cycle-tracks and pedestrian pavements must be wide enough. If cyclists do not have proper facilities of their own and share the use of pavements - in some countries bicycle tracks are painted on sidewalks - a lot of bicycle/pedestrian accidents may take place, some of them will be serious, a few even fatal.

The data show that cycling is not a safety problem in itself. When cycling is promoted by facilities, it may become safer than car driving. Of course, the quality of facilities will influence the safety level significantly.

4.2. New concepts for safety and other needs of cyclists

In this section a new approach for the design and the road infrastructure network is presented. The basis for this are three documents:

- Sustainable road safety system, developed in the Netherlands, to design road infrastructure in a way that the chance of fatal accidents is decreased to a great extent (SWOV, 1992)
- ‘Vision Zero’, developed in Sweden, to design road infrastructure in a way that fatalities are as far as possible excluded (Wramborg, 1998).
- ‘Sign up for the bike’, a Dutch manual to design facilities for cyclists that come forward to their mobility and safety needs (CROW, 1993)

The first two documents are approaches for road safety in a new way.
The main principle for a sustainably safe infrastructure is that every road is appointed a specific function and is designed such that the road or street in question meets the specific functional requirements as optimally as possible. The three different functions are rapid processing of through-traffic, rapid accessibility of areas, and accessibility of destinations.
Vision Zero has as one of their main principles the view that the level of violence that the human body can tolerate without being killed or seriously injured, shall be the basic parameter in the design of the road transport system.

In the concept of Sustainable Safety the further elaboration results in three main principles:

1. Functional use of the road network.
   Roads, intersections, cycle-tracks etc. have to be used as intended by the designer. Functional road categories are distinguished, and for each category the intended behaviour of the traffic participants is described.
2. Homogeneity of traffic.
   Homogeneity is described as: small differences in speed and moving directions of traffic participants and small differences in mass and vulnerability of traffic participants. Encounters with great differences in speed and direction have to be prevented.
3. Predictable behaviour in traffic.
   Choice of routes and manoeuvres for all traffic participants are always clear and simple.

The main principles of the Vision Zero are:

I. Vision Zero means that eventually no one will be killed or seriously injured within the road transport system.
II. It can never be ethically acceptable that people are killed or seriously injured when travelling along the road transport system.
III. The level of violence that the human body can tolerate without being killed or seriously injured shall be the basic parameter in the design of the road transport system.
IV. The designers of the system are always ultimately responsible for the design, operations, and use of the road transport system. They are thereby responsible for the level of safety within the entire system.
V. Road-users are responsible for following the rules for using the road transport system set by the system designers.

Both road safety concepts provide conditions for safer cycling, while the bicycle manual takes the different traffic functions of cycling as starting point. The manual is a guide to plan for cycling in a non-restrictive way, and making use of the five quality criteria for bicycle facilities: safety, coherence, directness, comfort, and attractiveness (see chapter 3).

4.2.1. Comparison of the road safety concepts

The main principles for prevention of road risk in the new concepts in the Netherlands and Sweden show great resemblance. The background of these concepts was the persuasion that the policy on traffic safety until now was no longer capable of reducing the present level of unsafety, and that a new and radical future scenario had to be defined to improve the situation. Both concepts state that if we wish to change the road safety situation radically, we must stop defining road fatalities as a negative, albeit largely accepted, side effect of the road transport system. Both concepts describe the road safety problem as a public health problem.

In both concepts, mankind and its limited capabilities is the starting point for traffic design. A good interaction between human factors, vehicle characteristics, and road features is envisaged. The road and street design should be focussed better on human shortcoming and limitations. In both concepts the aim is to reduce traffic conflicts as much as possible, and if conflicts can not be avoided, they do not result in fatalities or serious injuries.
Roads and streets, intersections, cycle-tracks, and other facilities have to be used as intended by the designer. Functional road and street categories are distinguished, and for each category the intended behaviour of the users is described.

Both concepts also aim for predictable behaviour in traffic. Choice of routes and manoeuvres for all traffic participants must always be clear and simple.

In both concepts, the classification in different road and street types, with well-described characteristics, is considered to be a very important item. The concepts are characterised by a limited number of categories of urban roads, clearly distinctive design, distinctly different types of streets, recognizability, and legibility of each individual type of road, making clear which behaviour is appropriate.

The basic assumption for the road and street classification is also identical in both concepts. Roads with a flow function require a design, which allow high speeds. This means that oncoming, crossing, and intersecting traffic should be made impossible. On roads with an access or distribution function, a relatively high density of junctions hinders complete segregation. But slow and fast traffic should be kept separate where possible. Where they intersect, the driving speed should be low or be separated in time. Roads with a residential function are meant for all kind of traffic. Low speed allows good anticipation and avoidance of hazards.

Both concepts identify and aim to create large and continuous residential areas with low motor vehicle speeds, a maximum 30 km/h, and mostly mixed traffic. In the Netherlands, local and national governments agreed that about 2/3 of the urban road and street network will in future be part of residential areas. In many countries, limits of 30km per hour are now being introduced.

In residential areas, pedestrians and bicyclists are allowed to cross the streets anywhere. In general no crossing facilities for pedestrians and cyclists are necessary because of the low speeds. But whenever there are special needs, for instance where many pedestrians cross a street, there will be physical measures as elevated crossings, designed as a pedestrian pavement on which cars are permitted not to drive faster than walking speed. The street design must be adapted to more-or-less force a low driving speed. Through-traffic will be kept out as much as possible. The design of the road categories will be easily recognisable.

In both concepts, the Ministries of Transport set goals. The goals for the Dutch Sustainable Safety are a reduction of injured victims of 40% and a reduction of deaths of 50% in the year 2010 compared to the situation in 1986. The goals for the Swedish Vision Zero is maximum 400 fatalities and 3,700 serious injured in 2000, and maximum 250 fatalities in 2007. The long-term goal of the Vision Zero is a situation with no fatalities and no seriously injured in road traffic.

4.3. Traffic Network and Street Design - A new and non-restrictive approach for European cities

The two road safety concepts Vision Zero and Sustainable Safety - dealing with road hierarchy for safety - and 'Sign up for the bike' - dealing with functional network design for cycling - can complement each other. One can start from both sides. Whatever approach is chosen, the complementary approach should serve as a check. If road hierarchy and functionality for cycling are in accordance, one can be sure of a safe and cycling supporting result. Moreover, the complementary approach could be an instrument in setting priorities for the implementation.

Below, the Vision Zero has been elaborated to fit into a non-restrictive approach to promote safe cycling. This presentation is not meant as the one and only solution, but as an illustration how to apply the main principles and to reconstruct the actual road network. This elaboration is called The New Approach.

A hierarchical division of roads and streets, based on speed, is now suggested in built-up areas as a key element of the New Approach:

I. Through-traffic route (70-km/h road) with only grade separated crossings
II. 50-30-road **(**Main street/Urban arterial road)
III. 30-km/h-road **(**Residential Street/Wohnstrasse/Rue Residentielle)
IV. Walking speed street (or 'Homezone' as they are called in Britain)
V. Car-free areas for pedestrians and cyclists.

This means that in built-up areas, the normal standard of 50-km/h-streets is changed to 50-30-roads, 30-km/h-streets and Walking speed streets, wherever pedestrians, bicyclists, and car traffic intermingle.

One advantage of this road and street classification is the possibility of including an accurate description concerning (*desired*) ***function****, (street)* ***design*** and (*traffic*) ***behaviour*****.** Below, these aspects are summarized for the five street categories. For a more detailed description see Leden and Wramborg, (1999).

4.3.1. 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 Through-traffic 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 prevalent traffic volume.

Design
The alignment of a Through-traffic route is often of high standard and as far away from nearby buildings as possible. The carriageway has often two traffic lanes for car traffic in each direction, sometimes even more. Pedestrians and bicyclists have been provided with grade-separated interchanges for crossing Through-traffic routes.

Behaviour
The speed limit of motor vehicles is mostly 70 km/h on Through-traffic routes. The speed at intersections may not exceed 50 km/h if there is any risk for a side (impact) collision

Walking and Cycling and Through-Traffic Route
Pedestrians and cyclists pass Through-traffic routes at grade-separated crossings. If there are not enough grade separated crossings, Through-traffic routes constitute barriers for bicycle and pedestrian traffic. Such Through-traffic will not be accepted.

4.3.2. 50-30-Road

Function
The 50-30-road is used by motor vehicles and by bicyclists going 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. Very often a 50-30-road is not a boundary between two neighbourhoods, and therefore pedestrians, bicyclists, children, the elderly, and disabled persons very often need to cross 50-30-roads.

Design and Behaviour
The carriageway normally has only two lanes for ordinary car traffic, one lane in each direction. This means an approximate width of about 6 metres between the kerbs on opposite sides of the street. The 50-30-road also has wide cycle-tracks and wide pedestrian pavements, affording pedestrians and bicyclists good accessibility, safety, and security.
An intersection between two 50-30-roads always has pedestrian and cyclist crossings. These crossings are designed so that a car cannot drive through them at speeds exceeding 30 km/h. The pedestrian and cycle crossings should be designed to meet the needs of children, elderly, and disabled persons.

Walking and Cycling on 50-30-roads
There are three very important reasons for constructing cycle-tracks along 50-30-roads. Firstly, this promotes cycling. Second reason is for safety. The third reason is to enable road-users to intuitively perceive that they are in a 50-30-road.

Bicycle track
50-30-Roads often have a straight, direct alignment. The cycle-tracks along these streets will therefore almost of necessity become a natural link in the trunk bicycle network. This means that they will be at least 2 meters wide for one-way bicycle traffic and at least 4 meters wide for two-way bicycle traffic. The high biking speed also motivates the necessity of taking measures to separate pedestrians and cyclists. A sufficiently wide pedestrian pavement and a sufficiently wide cycle-track should then be arranged; 2 meters would appear to be an acceptable minimum for both the pavement and the cycle-track.

Figure 4.1. *Design of a 50-30-road by Per Wramborg.*

The differences in speed and the differences in mass between cars and bicyclists mean that *a dividing strip (verge) at least 0.5 meter wide is necessary between the carriage-way and the cycle-track.* It is particularly important that there are different colours and textures on the parts intended for walking or biking respectively. It would be good if the pavement surface of cycle-tracks had óne particular colour, which is clearly different from the road surface for motorised traffic. A reddish brown colour is probably the most suitable. The pavement surface should reflect its intended use, with flat slabs or stones being a suitable material. As far as the cycle-track is concerned, asphalt would be the material most closely associated as a biking surface.

4.3.2.1. Safe non-restrictive crossing facilities

The design of crossing facilities is crucial. If ‘best practise’ is not used, traffic safety might deteriorate. The safety effectiveness of bicycle facilities is often reduced completely by a lack of proper solutions on crossings. A literature study of roundabouts shows that speeds do decrease at roundabouts but that the safety effects are not always those anticipated. And the safety effect applies mostly to the motor vehicles, and to a lesser extent to other vehicles. The efficiency is much increased when there is a proper design of the roundabout, taking into accounts all road users.

Principles

Some principles for crossing design are presented below.

There are typically pedestrian and cycle crossings at intersections between two 50-30-roads. These crossings should always be marked.

Only one incoming lane for motor vehicles is recommended. It should not be possible for a driver to overtake at pedestrian and cycle crossings.

In signal-controlled intersections, there should be no motor vehicles turning when cyclists and pedestrians have green.

There are strong reasons to design the urban cycle network so that cycle tracks are one-directional. Drivers do not expect cyclists from the ‘wrong’ direction. Therefore, two-directional cycle-tracks may deteriorate safety, see e.g. Linderholm (1992), Summala *et al*. (1996) and Räsänen and Summala (1998). There might be reasons however to opt for two-directional tracks, see e.g. ‘Sign up for the bike’ (CROW, 1993). In that case, special provisions are needed for safety.

Feelings of mutual respect can be supported by right-hand right-of-way, mini roundabouts and wide traffic islands. Green waves and priority roads (give way signs for entering roads) might deteriorate feelings of mutual respect.

Important countermeasures to improve interaction and reduce accident severity by *reduced speed* are:

I. speed reducing devices (raised cycle crossings, humps etc., see *e.g.* Rantatalo and Wikström, 1998)
II. refuges in crossings
III. mini roundabouts.

Important features to improve *visibility* and interaction are:
- Truncated cycle-tracks
- Advanced stop lines at signalised intersections
- Prohibited parking for cars 25 m from a pedestrian and cycle crossing (PCC).

Design

The design of some of the countermeasures will be further elaborated below.

- Raised pedestrian and cycle crossings

To improve interaction where 50-30-roads cross minor streets (30-roads, walking speed streets, residential streets, ‘homezones’) the pedestrian and cycle crossing may be raised to the level of the pavement. The pedestrian and cycle crossing may be designed as a pedestrian pavement motor vehicles would drive through at walking speed (see *Figure 4.2*). Leden, Gårder and Pulkkinen (1998) studied the effect on bicyclists' safety of raising urban cycle crossings to the level of the pavement. The results show that the raised cycle lanes attracted more than 50 percent more cyclists and that the safety per bicyclist was improved by approximately 20% due to the increase in cycle flow and with an additional 10 to 50% due to the improved design.

Figure 4.2. *Raised crossing using a rumble pavement to improve interaction.*

- Truncated tracks

A key element to safe crossing designs is improved interaction, by locating the cycle crossing at an intersection immediately next to the crossing street and remove the curb stone for a distance of 20 - 30 meters before the crossing with another 50-road. This design element is called *truncated* track, see *Figure 4.3*. The idea is to make the road users approaching a junction more visible to each other and make them being seen earlier, the risk of unexpected appearance is reduced and safety improved. The design prevents two-directional use.

To improve interaction it is also important to improve sight conditions. Car parking may be forbidden for a distance of 25 meters ahead of pedestrian and cycle crossings instead of the present-day 10-meter regulation. This would considerably increase the amount of eye contact and hence the interaction between motorists and vulnerable road-users, especially children, hereby reducing the danger encountered by pedestrians, bicyclists and motor vehicles at intersections between 50-30-roads. This is also a condition for truncated cycle tracks.

Figur 10. Forslag 1.

Figure 4.3. *Design of truncated cycle track (Herrstedt et al., 1994). The truncated track is separated from motor vehicle lanes by a wide painted rumble strip. A rumble pavement in the separation area between the cycle lane and the pedestrian pavement the last 20 - 30 meters makes cyclists ride closer to the motor vehicles and hence improve interaction between bicyclists and drivers of motor vehicles.*

- Advanced stop lines at signalised intersections

At signalised intersections an advanced stop line for bicyclists improves visibility, mobility, interaction and safety particularly for cyclists turning left. Sign up for the bike (1993) suggests alternative designs according to *Figure 4.4.*

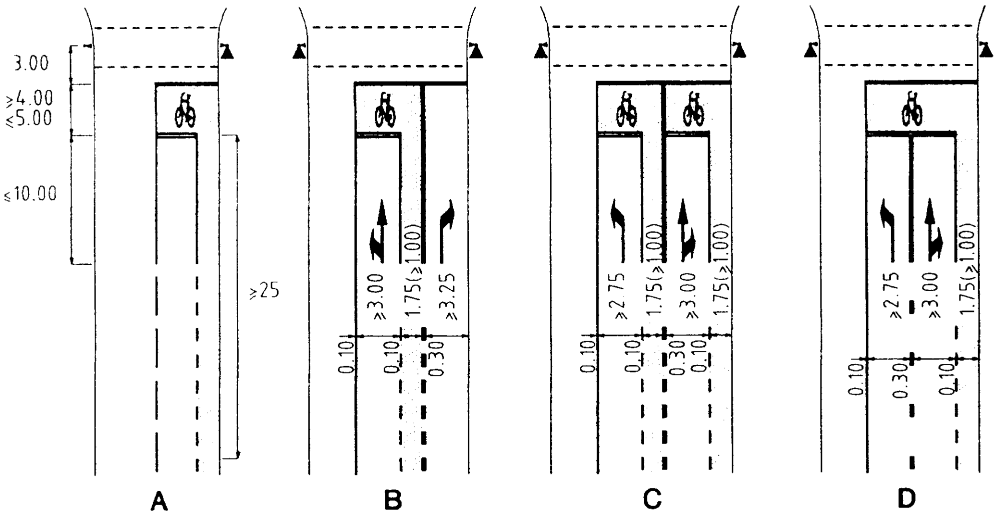

Figure 4.4. *Advanced stop lines. Source: 'Sign up for the bike' (CROW, 1993, p. 179). A = standard model, B = right-turning model, C = left-turning model, and D = left-turning model without a separate green phase.*

- Speed reducing devices (humps)

Vertical measures such as road humps and speed cushions often have greater speed reducing effect on passing vehicles than horizontal measures, such as chicanes and width restrictions of the carriageway. The speed reducing effect of a speed-reducing device is strongly dependent on the detailed layout and on the surrounding environment and traffic structure in the area.

If properly designed, mini roundabouts increase cyclist's safety. There are three common types of design:

I. no special facility for cyclists in the roundabout with one lane approaches,
II. separate cycle track with ordinary pedestrian and cycle crossings (PCC) around the roundabout,
III. a special cycle lane within the roundabout with one lane approaches.

Brüde and Larsson (1996) and Hydén and Várhely (2000) recommend design 1, a single-lane and comparatively small roundabout with no cycle lanes, see *Figure 4.5*. According to 'Sign up for the bike' (CROW, 1997, p. 183) design 1 can be feasible for motor vehicle flows lower than 8,000 motor vehicles per 24 hours. For higher motor vehicle flows, design 2, a separate cycle-track with ordinary pedestrian and cycle crossings around the roundabout, is recommended (Brüde and Larsson, 1996, and Herrstedt *et al* ,1993). Design 3, a special cycle lane within the roundabout with one-lane approaches, is not recommended.

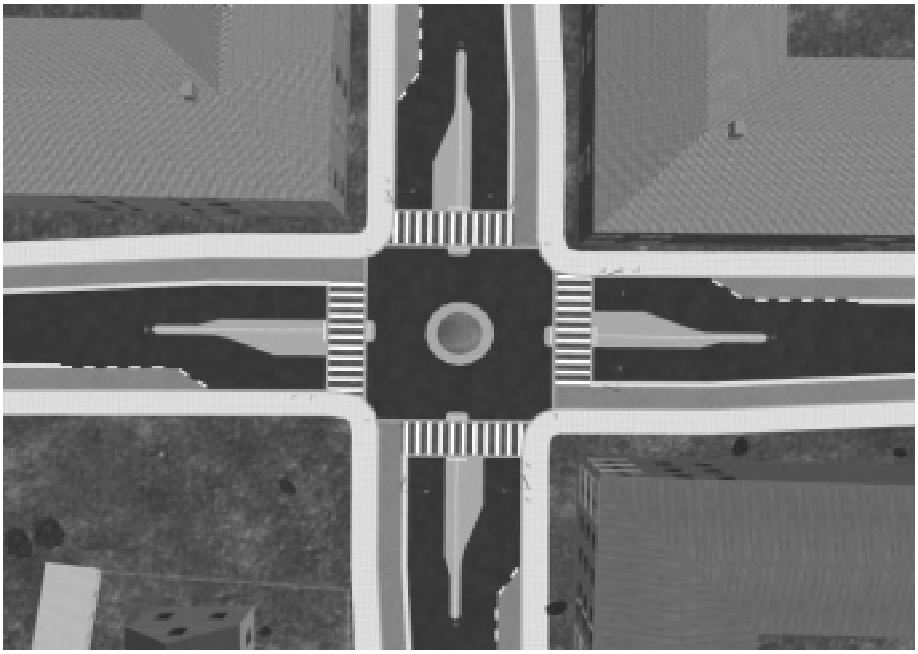

Figure 4.5. *Mini roundabout with no special facility for cyclists in the roundabout and one lane approaches.*

4.3.3. 30-Road

Function

The 30-road is a street in a residential area, where priority is given to the local inhabitants, thus designating its function. The 30-road shall be an attractive, pleasant street space, and an environment suitable for children, the elderly, and disabled persons.

As far as vehicles are concerned, a 30-road is used only by local car traffic that originates in or has a destination within the neighbourhood. For motorised vehicles, 30-roads nearly always have access traffic, sometimes collector traffic, but never through-traffic. For cyclists, 30-roads may have a distribution and also a through-traffic function, since cyclists need smaller margins in their network.

Design

Apart from streets with a through-traffic function for cyclists, a 30-road has pedestrian pavements and a carriageway. The carriageway is as narrow as possible, i.e., between four and six meters. Thus, there is space for the pedestrian pavement to be as wide as possible, providing great potential for creating an attractive, pleasant street area suitable for children, the elderly, and disabled persons alike. The manual 'Sign up for the bike' points at the necessity to avoid situations in which cars just can pass cyclists.

Especially in the inner city areas, 30-roads provide part of the need for short-time parking. Parking spaces are designed and located with care, paying consideration to their being an aesthetically attractive element within the street environment.

Traffic calming measures guarantee safe, secure interaction between pedestrians, bicyclists, and motorists. One good traffic calming measure is an elevated crossing, signalling that in residential areas priority is given to pedestrians. Motor vehicles must pass an elevated crossing at walking speed.

Behaviour
Still, within a residential area it is natural to cross a street as a pedestrian or a bicyclist arbitrarily, either anywhere along the street or at street crossings.

Walking and cycling on 30-roads
These roads are designed with varying kinds and levels of traffic-calming measure. It goes without saying that cyclists can use the entire width of a 30-road and cars can be required to wait before overtaking until this can be performed without risk of danger.

A 30-road may be one-way for cars. Mostly it is not necessary to make such a street one-way for cyclists as well.
A main route for cyclists and a cycle street can cut across a 30-km/h area. Such routes and cycle streets are characterised by distinctly more through-bicycle-traffic than can be found on a normal 30-road. One possible reason for this situation could be that the 50-30-roads in the vicinity, are so far apart that they are unable to capture all the fast-moving bicycle traffic on the cycle-tracks on 50-30-roads. Cycling is very much affected by detours, and needs therefore direct routes. The design of a cycle street reflects the extremely important conditions and behavioural aspects mentioned in the foregoing.
The pedestrian pavements along 30-roads are to be wide enough to allow for parking bicycles without jeopardising the intended use of the pavement. The type of bicycle parking in mind would primarily be in bicycle stands or by locking the bicycle onto a fixed object.

4.3.4. Walking speed street

Function
The Walking speed 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. A Walking speed street is an attractive, pleasant street space for meetings, play, and recreation. It is used by motor vehicles only when they come from, or go to a destination along it, or a street close nearby.

Design
The entire Walking speed street is intended for everybody; it is not divided into separate lanes for different types of “traffic”. It is designed entirely at the same level; i.e. there are no curbs.

Behaviour
Pedestrians and bicyclists always have the right-of-way.
The Walking speed street is designed and regulated so that the maximum speed for motor vehicles does not exceed walking speeds; i.e. 5 to 10 kilometres per hour. This type of street has often been created on the initiative of the property owners and the local residents, with both groups supporting the construction and maintenance operations.

Walking and Cycling on Walking Speed Streets
Children, elderly, and those not used to cycling ought particularly to appreciate being able to cycle here. The major purpose of Walking speed streets, i.e. being a pleasant and attractive outdoor area for those living and working along the street or in its immediate proximity, means that it cannot be used for cycling, either at high speeds, or large numbers.
The melange of residential area streets, 30-km/h-roads and Walking speed streets, should mean that bicyclists do not have to travel at walking speed for more than a few hundred metres, and this normally occurs at the beginning and at the end of a trip.

Walking speed streets should be designed so that bicycles can be parked on the street without jeopardising its intended purpose. The type of bicycle parking in mind would primarily be in a bicycle stand or by locking the bicycle onto a fixed object. The type of parking where bicycles are completely locked away inside would not normally come into question on walking speed streets.

4.4. Context

Finally, some pragmatic advice is given in *Scheme 2* to summarise this chapter and to highlight the context for some of the countermeasures discussed in this chapter.

Scheme 2. *Towards a walk and bicycle friendly city – some pragmatic advice to promote walking and cycling by improving the cycle network*.

I. Analyse origin and destinations for (potential) bicycle trips and create a coherent network for facilities with a through-function, respectively. distribution function for cyclists.
II. Build green streets where any confrontation with motor vehicles is practically non-existent, in green corridors, for instants in park areas, without motor vehicles and with grade-separated intersections where the paths intersect with high-volume or high-speed roads.
III. Build significant shortcuts for pedestrians and cyclists, for example connecting cul-de-sacs and providing grade separated crossings, to improve safety and mobility.
IV. Build cycle tracks along all 50-30-roads.
V. Gradually ensure that motor vehicles do not drive through at-grade pedestrian and cycle crossings (PCC) at speeds above 30 km/h. If necessary, physical traffic calming measures are to be used.
VI. Build special routes for cyclists or cycle streets (Fahrradstraßen) in residential areas where priority is given to cyclists.
VII. Ensure that cars do not drive at speeds above 30 km/h in residential areas. If necessary, physical traffic calming measures are to be used.
VIII. Build separated pedestrian and cycle paths, green streets, along Through-traffic routes and grade-separated intersections where pedestrians and cyclists cross Through-traffic routes.

5. REGULATIONS

5.1. Introduction

In the framework of developing non-restrictive measures for cyclists, regulations may pay an important contribution to enhance the protection of cyclists and to enhance their rights to make an efficient and comfortable use of the road.
This chapter will concentrate on traffic rules and the rights and responsibilities of the road users. The description of actual regulations in European countries is mainly based on a German study by the Bundesanstalt für Straßenwesen about comparisons of traffic regulations in Europe (BASt, 1997). The BASt made an inventory of the European agreement on traffic rules, from Vienna in 1993 and they refer to national regulations in Germany, France, UK, Switzerland, the Netherlands, Spain, and Italy. Another source of information about regulations is the OECD report about vulnerable road users. They describe also relevant regulations in e.g. Scandinavian countries.

Differences between countries regarding manoeuvres illustrate how rules can be made more or less restrictive:

- In general, cyclists have to overtake cars on the left side (in the UK and Ireland on the right side). There are however exceptions in several countries. In the Netherlands cyclists may chose for themselves to overtake cars on the left or right side. This is the most efficient for cyclists and can also be most safe, when drivers learn to leave room for cyclists.
- In general, it is not allowed for cyclists to ride side-by-side, unless this is not causing danger or hindrance. In the Netherlands this is allowed in general. The infrastructure has to provide cyclists the opportunity to ride side-by-side as the general rule. Just as car passengers do, cyclists must have the opportunity to communicate with each other.
- Many streets in urban areas are too narrow for two-way traffic of motorised vehicles, so signs indicate that this a one-way street. But such streets are not too small for cyclists to ride in two directions. Cyclists should therefore be excluded from the restriction to make use of the road in only one direction. The more one-way streets are created to restrict car use, the more important this is, because cyclists get a real advantage on motorised traffic in travel time. In the UK and the Netherlands, it is allowed for cyclists to ride on one-way streets in both directions, when this is indicated with a sign. This rule was also recently introduced in Germany. It is important to keep the width for cars restricted, because otherwise the introduction of one-way traffic for cars may provoke higher speed.
- a new solution to make room for cycling and to calm motorised traffic is the introduction of cycle streets, e.g. in Germany where cyclists may make use of the whole street and cars may not overtake. Especially on small roads with only an access function for cars, a bicycle street can be a good solution.

5.2. Main principles

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 juridical responsibilities in case of accidents.

A legal framework in itself does not ensure a quality approach, but helps to formulate policy aims and the rights and responsibilities of road users. Regulations and technical and non-technical measures should be integrated to guarantee the enforcement of the regulations.

5.3. Review of current situation

5.3.1. Legal responsibilities

From a road safety point of view, the position of cyclists and pedestrians in road traffic is often labelled as ‘weak’. The ‘Treaty of Vienna’ from 1993 states: “Drivers should be extra careful to the most weak road users such as pedestrians and cyclists, particularly with respect to children, elderly people and disabled people”. Another label is the term ‘vulnerable’, to make clear that pedestrians and cyclists are not protected by a bodywork in the way car drivers are to the speed and mass of motorised vehicles.
For the promotion of cycling as means of transport, the labels “weak” and “vulnerable” are not inviting. With respect to the urgent need to cut down at least the growth of car use, to preserve our cities and villages, and to combat congestion, pollution and noise; cycling and walking have become a strong case.
Nevertheless, the mobility and safety of cyclists demand that they be better protected. So the obligation to drivers or riders of motorised vehicles to be extra careful regarding pedestrians and cyclists, as stated in the ‘Treaty of Vienna’, is justified and has to be translated in responsibilities. The motivation may be that pedestrians and cyclists have equal rights for a safe, efficient, and comfortable journey.

5.3.2. Standards for facilities

The OECD report on vulnerable road users evaluated the traffic policy in this respect. The road policies in the 1960's and 1970's were marked by the rapid expansion of car ownership. Roads were built and widened to accommodate growing car traffic flow with often disastrous effects to vulnerable road users. On top of this, the limited space allocated to pedestrians was not always properly maintained, and tended to be obstructed by all sorts of obstacles, including traffic signs. No particular attention was paid to pedestrians’ needs in terms of network to facilitate walking across a city, the report says. These conclusions can also be drawn regarding cyclists.
The OECD report further states that with the “woonerf-concept in the Netherlands, it was acknowledged by decisions makers that urban streets could have another function than just providing mobility for motorised traffic”. Only in the 1980's, the idea of comprehensive networks for pedestrians and cyclists started to make way in some countries, thus acknowledging walking and cycling as a fully-fledged means of transport. The idea that fast-motorised traffic may have to yield priority to local traffic and vulnerable road users in some parts of urban areas, finally became acceptable.
This has been reflected in new highway codes and design manuals. In Chapter 4, good standards for cycle facilities on the road have been described. Taking into account these requirements for cycle friendliness, traffic rules may be adjusted.

5.3.3. Sharing the road

In most European countries, cyclists have to make use of bicycle facilities, and if they are not available, to make use of the road for motorised vehicles. But cycle facilities have to meet good standards. In some countries, for example Norway, cyclists are allowed to ride on the road even if cycle tracks exist, if it is more suitable considering the destination, and if done with extra care. This rule has two advantages: it is less restrictive and it provides a stimulus for road administrations to create good facilities.
In general, cyclists are not allowed to use footpaths, but in some countries this is allowed, indicated by signs; this is even an obligation. Pedestrians however may feel threatened by cyclists and sharing the footpath with pedestrians often withholds cyclists and pedestrians sufficient room and prevents cyclists from an efficient way of crossing streets. In general, cyclists and pedestrians need their own facilities.

When cyclists have to share the road with motorised vehicles, drivers have to adapt their behaviour to cyclists (speed, attention). Standards for the choice between separation and integration have been given e.g. in the Dutch manual ‘Sign up for the bike’ (see chapter 3).
In general drivers are obliged to keep sufficient distance to cyclists when they overtake. In Spain 1.5 meters is required, in the Netherlands and France 1 meter. Cyclists are obliged to ride on the right of the road or lane (in the UK and Ireland on the left), apart from crossing manoeuvres. Although this rule for cyclists is justified in general, there is an argument for cyclists not to ride just as close to the edge as possible, when this provokes motorised vehicles to overtake when this is hardly possible. A cyclist is always affected by an overtaking manoeuvre and needs space to keep control and not to collide. Also the needs of tricycles, e.g. used by disabled people, and the needs of cycle carts for e.g. children, have to be taken into account.

5.3.4. Crossing

In chapter 4, design features for crossing have been presented. Apart from roads with a through-traffic function for cars, in urban areas first priority for cyclists and pedestrians may be introduced more or less as the rule. Technical measures are needed, supported by rules.

Two main principles for highway codes and guidelines may be taken as a general approach:

1. The waiting time for pedestrians and cyclists at crossings should be minimised, providing them with equal rights to motorised traffic,
2. In urban areas with the exception of some roads with only a traffic flow function for cars, walking and cycling should receive first priority.

Possibilities are:

- advanced stopping lines at crossings with traffic lights, to enable cyclists to wait in front of motorised traffic and to continue first,
- leading phase for cyclists and pedestrians,
- traffic lights that provide a green phase for 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 the right to turn right when motorised traffic have to wait for red light.

The rules with respect to turning to the left (in the UK and Ireland to the right) differ. In some countries cyclists may choose to turn directly; manoeuvring to the middle of the road before the crossing; or indirectly. In other countries cyclists are not allowed to turn left in a direct way. This is too restrictive.

5.3.5. Parking

Parking of the bicycle is in some countries restricted, to enable sufficient space for pedestrians or to avoid danger. This is reasonable, but there is a lot of evidence that the lack of good parking facilities is restricting bicycle use, especially because of the fear of theft. So a good bicycle parking policy is needed, as a precondition for the use of the bicycle and also to avoid problems for other road users, especially pedestrians and disabled people.

5.4. Implementation

Planning for the needs of cyclists and pedestrians and traffic calming are most important to enforce rules. But also education and information are needed to explain the background of the rules and to give behavioural recommendations. And also the police should keep control.

As an illustration:

Germany recently amended the traffic code for cyclists. Some new elements are already mentioned, like contra-flow cycling in selected one-way roads and a code for bicycle streets. Besides, shared use of bus lanes, cycle lanes on roads, and various marking solutions for junctions are involved in the changes. Cycle tracks can only be made compulsory if they fulfil on 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.

6. VEHICLE REQUIREMENTS

The traffic system can only work well if the elements man, vehicle, and road are fitted well together.
Vehicle requirements are mainly needed for riders and drivers to keep control, to support observation of each other, and for injury prevention.

In this chapter, requirements for the bicycle and for other vehicles that are important for the safety of cycling, are reviewed. Also personal equipment for injury prevention, bicycle helmets, are considered.

6.1. Bicycle equipment

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 selective yellow lights in front and red lights on the rear, according to the Vienna Convention (BASt, 1997).
However, a minority of bicycles are not meeting legal norms. In Germany it was found that 32% of bicycles in Nordrhein-Westfalen had technical defects (Hansen, 1995). In the Netherlands, 45% of cyclists did not have lights burning during darkness (Schoon and Varkevisser, 1996), while a survey in Scandinavia showed that 35% of the cyclists did not have correct lights (Hansen, 1995).
It seems reasonable to require from the manufacturers more solid and sustainable devices, also taking into account winter conditions. Unfortunately, the quality of the bicycles and their devices is not sufficient on average, and the competition is too much directed on low prices. But in the end the consumer has to pay, and failing devices put cyclists more at risk than necessary. A study in the Netherlands (Schoon, 1996a) found that a technical cycle defect was cited as the principal cause of the accident by 7% of cyclists aged twelve years and older, being treated at the Accident and Emergency (A&E) department of a hospital. 8% of older cyclists indicated that the accident would (or might) have been prevented if the cycle had been better maintained; in most of these cases, the condition of the brakes was poor. In Norway and Sweden, according to a summary of several surveys, 10% of cycle accidents are due to defective bicycles (Hansen, 1995).
Reliable and sustainable devices make the requirements the least restrictive, because if the devices do not work properly, and when they have to be repaired, the bicycle will be used less.

In this respect, national and international norms are important. At the European level, ISO is currently reviewing the norms for bicycle lighting systems. Indicators for quality are e.g. the function, material-requirements, and sustainability. Colibi, the platform Lighting Equipment of the Organisation of the European two-wheeler parts industries, installed a steering committee to formulate point of views regarding fair trading, road safety, and harmonisation. From the viewpoint of the users, solid equipment and comfort while riding with the dynamo, are important (Schoon and Polak, 1998).
In e.g. the Netherlands, Germany, and the UK, reflectors are compulsory on the wheels, at the back and on the pedals. In Germany and the UK they are also obliged at the front. For the users it is important to be seen, and reflectors are effective in addition to lighting.
In the Netherlands (Blokpoel, 1990) it has been calculated that the increase of side reflectors from 10% to 70% results in 4% less injured cyclists during darkness.
In the Netherlands, SWOV rated the introduction of reflectors on the front of new bicycles as a moderate cost effective measure (Schoon and Polak, 1998). The potential of reflectors on

the front to reduce injuries has been estimated at about 4% during darkness. When the manufacturers agree on the requirements, and would install the reflectors on all bicycles, this could be a cost-effective measure.

Accidents because of a child’s feet trapped between spokes, have a significant share in all accidents with bicycles, at least in the Netherlands: it contributed to 73% of all accidents amongst bicycle passengers, in total 2,700 people (Schoon, 1996). In 60% of those cases, the bicycle was not fitted with a wheel spoke cover, and in 15% of the cases the cover was broken. ISO designed norms for child seats on the bicycle, but these norms do not have any status yet. The norms are far more extensive than national norms, but are still not optimal and are in discussion. In the Netherlands it was not possible to calculate the cost effectiveness of the introduction of child seats according to safety standards. There is no data about the numbers of seats being used and their quality.

In the Norwegian Traffic Safety Manual (Elvik, Mysen and Vaa, 1997), effects of bicycle safety devices are described. For most of them the effects on the number of accidents is, however, unknown. The best estimate for a gear system versus no system is 17% less accidents. Spoke protection versus none could decrease the amount of such accidents by 37%. Further, it was calculated that racing handlebars lead to far more accidents than ordinary handlebars. Also bicycles with more than 5 gears are involved in more accidents than bicycles with less than 5 gears.

Safety pennants contribute to the gap left when overtaking, according to a Finnish study (Koivurova, 1987). The use of safety pennants reduced the number of extremely close overtaking even in the most critical situations.
Also spacers have positive effects according to a study by TRL (Watts, 1984). The percentage of overtaking vehicles passing less than 0.8 m was approximately halved, when using a spacer of 0.5 m. A spacer of 0.35 m was only about half as effective. Another study pointed at maintenance problems and problems when riding side-by-side.

6.2. Helmets

Helmets reduce the severity of head injuries. In Europe there is no obligation to wear them (ECF, 1998), but this is in discussion in Spain.
There has already been a debate about this for a long time. From the point of view of restrictiveness, even the official promotion of helmets may have negative consequences for bicycle use. There are in this respect different cultures in Europe. To underline the use of a helmet, the message is often that cycling is extraordinary dangerous. This report shows however, that refraining from bicycle use has much more negative consequences for health than increasing bicycle use without a helmet.
To prevent helmets having a negative effect on the use of bicycles, the best approach is to leave the promotion to the marketers of the manufacturers and shops. This way, helmets may become a natural part of the cyclists’ equipment, like in Finland and Sweden. Officials should take the responsibility to create safe conditions for cycling. This is how helmet use and a greater use of the bicycle may go together.

In this case, the development of norms for helmets and information about their quality, remain important instruments to support people who want to use a helmet. So the development of helmets that come forward to the needs of cyclists, and are worn on a free basis, can be considered as a technical non-restrictive measure (although even voluntary wearing may be considered as restrictive because it might create a dangerous image to cycling).

6.3. Requirements for other vehicles

Improvement of requirements for other vehicles is a discussion at national and European level about costs and benefits. This can have as a consequence that injuries of cyclists are overruled by the costs for the buyers of a car or truck. It is a political decision to introduce new legal requirements that are more coming forward to the safety of different categories of road users.

Two subjects are of importance here.

The first regards *soft noses of cars*. There have been studies, e.g. by SWOV and TRL, claiming that soft noses are cost-beneficial. However, the Association of European Car Manufacturers has another opinion, and within ETSC and the European Experimental Vehicles Committee WG17 the debate is going on.

The second regards *side impact protection for trucks*. E.g. in the UK in 1983, legislation requiring side impact protection to be fitted to new Heavy Good Vehicles was introduced. The type of sideguard specified was designed to prevent pedal cyclists, motor cyclists, and pedestrians from being run over by the rear wheels of such vehicles. Research into the effectiveness showed that fitting a sideguard conforming to the minimum legal requirements can be expected to reduce fatal injuries to pedal cyclists in collision with the side of a truck by two-thirds compared to not having a sideguard at all. Reducing the ground clearance, increasing the length, and presenting a smoother, flatter external surface, would reduce fatalities and serious injuries still further.
If the cost of fuel savings from improved aerodynamic performance are included, the initial investment would be repaid over 12 to 14 years (Knight, 1998). It is concluded that the use of solid panel-type glass fibre sideguards with a ground clearance of less than 350mm should be encouraged and that the current list of vehicle exemptions allowed by the regulations should be reviewed to ensure that they are all justified by their mode of operation.

In the Netherlands, the same kind of calculations resulted in the estimation that 30 to 40% of cyclists being killed or injured in an accident with a truck, could have been saved by side protection. Fuel savings can be 4-5% (Schoon, 1996b). Also in this case, the investment costs can be recovered after a certain period.

7. EDUCATION

7.1. General principles

Education goes together with a comprehensive approach on road safety and mobility. It helps people to acquire capabilities and understanding, to make a good use of the road system. In many countries, children receive some traffic education directed at cycling. Parents usually train their children a little to control the vehicle, and besides they warn them where they are allowed to cycle. Much more is not taking place, and this is far from what should be done.
Besides this, information campaigns take place, to promote cycling or to promote safety. It is important that promotion is combined with providing good facilities, to show that cycling is taken seriously by officials too. Moreover, people will be more easily attracted to information when new products are offered.

Education and promotion can, however, not compensate for a bad design of the road.

Safety education can very well be combined with education about the advantages and benefits of cycling, and it is logical to combine these.
The advantages for 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, for the environment, the city climate, making good use of available space, and prevention of congestion etc. are very good subjects for lessons in primary and secondary schools.
In courses, the education aims for mobility and safety can also combined very well. To teach safe behaviour means also to support the mobility. And since safe behaviour can only be learned in practice, safety progress depends on mobility.

Road safety education consists of teaching skills, knowledge, understanding, and behavioural patterns, to enable road users to prevent accidents. It takes places at primary and secondary schools, driving schools, and at courses.
Road users however learn the most by themselves in practice. Therefore, education needs to be directed at providing a basis for the learning process in traffic. Safe behaviour cannot be learned without practice. If education is not adjusted to the learning process of road users on their own, it cannot be very effective.

Skills are a precondition for safe behaviour. Only when a rider or driver has automatic control of the vehicle, can he or she pay sufficient attention to other traffic. It takes, however, time before these skills are fully acquired.
Knowledge about transport alternatives and traffic rules is another precondition. The advantages and disadvantages of using different modes of transport related to circumstances, can be taught. Many traffic rules are not very well respected, and safe behaviour adapted to situations and circumstances can not be fully arranged by rules. Therefore it is necessary to learn to apply rules and behavioural recommendations to actual and situational conditions.
Rules have to be understood in a general framework of *understanding* the transport traffic processes.
So skills, knowledge, and understanding are only preconditions for safe behaviour. They do not guarantee safe behaviour. This means that road users have to learn for some years how to ride and drive relatively defensively during their period as a novice.

To summarise this, crucial for safe behaviour are:
- *control of the vehicle by skills and defensive behaviour,*
- *control of situations by understanding of road conditions.*
Both demand defensive behaviour, leaving the opportunity to stop and avoid other road users and obstacles;
- *understanding and communication*, to make good estimations of transport alternatives and of the traffic behaviour of others, to give other road users the opportunity to make good estimations of their own behaviour, and to anticipate threats in order to prevent a collision with other road users.
- *Behavioural patterns* are helpful to perform routine traffic and transport behaviour. This is especially helpful for children who cannot understand and interpret what is safe behaviour.

7.2. School education

Children start to learn about traffic already before they go to school. They look around, see what others do, make their interpretations, listen to what others tell them, feel the fear, pleasure, aggressiveness, and other emotions of the people who accompany them. They understand more than we think and it is right therefore, to show how to keep control of traffic situations and to teach them already in a simple way about right behaviour.
It is very important that schools provide a curriculum about traffic. When children are e.g. 12 years, they should know about the main characteristics of roads and of the different traffic modes and about traffic rules. They also should understand how to fulfil mobility needs and also know about characteristics of behaviour of different modes of transport and different road user groups.
The best basis for learning is their own experience.
It is not easy to organise, but the best way of road safety education is to give instruction in the traffic situations that the children have to deal with. Teachers and parents both have a role in this. Teachers can combine their explanations about the traffic system with the experiences of the children. Since much training is needed, parents should do most of this work. Therefore it is important that both teachers and parents receive materials about how they can instruct children. This also may stimulate parents to show right behaviour for children.
This approach differs from the approach that is usual. Usual is to teach children about all the traffic rules and to hope that they apply them. But a part of these rules are not relevant yet for children. So it is not easy to understand and apply rules when you are not familiar with them. Moreover, other road users do not apply the rules in a strict way, and the situation on the road also requires to often apply the rules less strictly. Teaching behaviour in traffic is far more effective.

Traffic education should continue at secondary schools. Children are now able to analyse the costs and benefits of different modes of transport for mobility, safety, health, the environment, the quality of life in cities and villages etc. They can also analyse more deeply the characteristics and interaction of roads, vehicles, and people.

7.3. Driver instruction

The potential contribution of education to the safety of cyclists is only partly related to education of cyclists. Education has an important role to play in creating good adaptation to and co-operation between road users. That is why driver instruction should include knowledge about the characteristics of cyclists’ behaviour and the right anticipatory behaviour to cyclists.

Apart from the training of skills, knowledge and behaviour, two central themes for an instruction programme are recommended in this respect.
The first is adaptation of speed to the speed of other road users with whom the driver has to share the road. This is a very important precondition for safe behaviour. Of course, keeping to the limit is necessary, but in many cases this is not enough. Also adaptation of speed according to circumstances like rain, fog etc. is important.
The second is to learn to communicate with other road users. Traffic rules do not really predict behaviour. Most important is not what others should do but what others intend to do. It is also important to learn about the skills of other road users, given their mode of transport, age, and handicaps. E.g. if you are familiar with two-wheelers, you know how they try to use small gaps to pass slow moving cars, how they cross streets anywhere to reach a destination in an efficient way, and what body movements they are making before making a certain manoeuvre etc. Defensive behaviour facilitates the learning process.
It would be good if novice drivers learn during instruction that cycling for short trips may be safer for them.

7.4. Implementation

It is not possible for an outsider to advise on the organisation of education and instruction and on the support that should be arranged, without close co-operation with the national and local executives. Support is very important, to share the responsibilities with teachers, parents and instructors, to keep in contact about their needs for fulfilling their duties, and to get a kind of quality control.
So it would be good if governments pay for specialists who support teachers, parents, and instructors with materials, making a program, organising practical education etc.

Education and instruction regarding the safety of cyclists, should have another content in a country, region, or city where cycling is already common and with good infrastructural facilities, than in situations without much cycling and facilities. Different kinds of regulations and different qualities of facilities for cyclists have to be taken into account.
Education teaches people what kind of behaviour they may expect from other road users, and this behaviour differs according to the facilities, and also according to the density of cyclists. But it is not only education and instruction that counts, because as said before, people learn much by practice, from experience. In a country like the Netherlands, most of the road users are experienced cyclists. Although road users tend to be selfish and e.g. as a car driver, act in their own, they have a bigger repertoire of expectations of the behaviour of others when they have wider experience. So in countries with less cycling, more energy has to be put in education and instruction to protect cyclists.

Regarding the combination of safety and mobility aims, the context is also very important. Although also in bicycle countries, people still may learn a lot about the benefits of cycling; in countries with less cycling, there will be more to explain and teach about this.
It is also interesting to learn about the transport and traffic in other countries, to reflect on national situations.

Moreover, it is important to combine the implementation of technical measures and the provision of facilities, with education. E.g. the reconstruction of crossings into roundabouts on a school route, should lead to an instruction programme at school about the consequences of behaviour. On the other hand the needs for facilities for cyclists can be analysed in an education programme, and the results should be presented to the local government.

7.5. Examples

Some examples from the Netherlands show what can be done.
An education program has been developed for parents to teach their cycling children between 8 and 10 years, to interact with other traffic on the road. Often parents are not a good example for their children because they behave like experienced and skilled cyclists, while their children need to ride in a defensive way. So parents are instructed how to accompany their children and to instruct them. This offer of help was accompanied by an urgent request to stop bringing children to school by car.

For elderly people, a course has been developed with the objectives to stay fit and healthy, to enable cycling, and to learn how to adapt their behaviour in order to be safe. Because certain skills are less functioning, defensive riding becomes also important for elderly people.

For mentally handicapped people, a special education programme has been developed. It turned out that this kind of programme is very rewarding for handicapped people, they experience making progress. The programme consists of sixty lessons, partly theoretical, partly practical.

In the Netherlands, there is also a need for a cycling training programme for adults, especially women who lived as a child in Turkey or Morocco and never cycled there. Many Turkish and Moroccan women want to become independent from the car of their husbands, or public transport services. As a result, the need for a separate cycling course became apparent. Lessons are given until the women feel able to cycle into the city centre independently.

8. IMPLEMENTATION

When we want to plan for the bicycle, we have to take into account the context of a city, region, or country. The context can be specified rather well by three kinds of conditions:

1. the current level of cycling and of the ownership of bicycles;
2. the physical structure, in terms of existing infrastructure and land use patterns;
3. the institutional support system, e.g. bicycle friendly policies and facilities.

The situation in Europe is quite diverse (see chapter 2). In this chapter we will describe the main principles for an implementation strategy. We will illustrate these with what we see as good examples, given the context of actual use, policies, and conditions.

8.1. Aim for connections and network

Bicycle policy often starts with some measures at sections of the road, creating a bicycle lane or a path. But to interest people to make use of a bicycle, a good connection between the origin and the destination is what counts. Compromising on junctions and crossings can be risky. Therefore it is necessary to design measures in the framework of connections, providing for facilities all along, and for the longer term, to aim for a network with main routes and direct access to destinations. Here we want to refer to the five criteria for a non-restrictive policy: directness, coherence, comfort, attractiveness, and safety; elaborated in chapter 3.

In some cities, recreation areas and parks may be the best starting points for the first routes of a bicycle network. For commuting, the bicycle is a very good option for trips of 5 or more kilometres.
Density greatly helps to make short journeys more common, favouring the choice of bicycles as a mode of transport. The density cannot easily be changed, but land-use policies which site work, leisure, and shopping facilities close to living areas, will help. The reverse will lead to greater car use. In the UK, the average trip distances for shopping have risen significantly in 20 years. Some of this rise can be attributed to the increase in out-of-town shopping centres. Changing land-use will require strict planning controls that combine transport, land-use, and environmental policies.

Networks can be very successful in releasing suppressed demand for cycling.
Switzerland opened in 1998 a nation-wide network of cycle routes covering the whole country, and the links between cycles and public transport are very well developed.
In 1996-7 some 100 kilometres of on-road cycle routes were built in Paris. These routes are mostly taken from road space, not pedestrian space. Cycle use there was 1% in June 1996, by September 1997 it had risen to 5%.
It does not have to be done that quickly to work well. Munich has doubled cycle use from 6% in 1976 to 15% in 1992 by building up a good network of cycle routes (Brög, 1995). This pattern has been repeated elsewhere.
The greater the accessibility and coverage of the network, the more useful and popular it will be. There is obviously much suppressed demand, and cities should not install 250 meters of cycle route and expect cycle usage to jump to use it.

8.2. Involve the road users

The best way to know if measures for cyclists will work and serve the needs of cyclists, and if they provoke a good use of facilities and safe behaviour, is to involve representatives of the cyclists in the planning process. In any country, even if there are hardly cyclists on the road, there is an advocacy group for cycling. Cyclists Unions in Europe have a European Cyclist Federation and the ECF organises every two year a Velo City Conference. So there is a lot of exchange of information and experience that may be very helpful for the politicians and planners. Moreover, in cities and regions with less cycling, designers may not be cyclists themselves. The criteria for quality of bicycle facilities have to be implemented according to local circumstances. For this, the cyclists themselves are the best proof of the pudding. They know the characteristics and limitations of cycling regarding pavements, curves, gradients etc.
In the Netherlands, the cyclist union is represented in advisory committees and platforms on the national, regional, and local level. Barcelona has set up a bicycle commission including user-groups and others, to implement a city-wide cycle network.

8.3. Involve the community

A cycling policy is not only beneficial for people who want to make use of a bicycle. The benefits of cycling are becoming more and more clear for fitness and recreation, cycling is a cure for stress, and prevents coronary heart diseases.
Cycling contributes to the residential function of neighbourhoods and to the city climate as an alternative to car use. Traffic calming has been an political issue all over Europe already for a longer period, but communities are still asking for more policy in this direction and the road safety strategies in e.g. Sweden and the Netherlands integrate this in the whole traffic system (see chapter 3).
Cycling also contributes to prevention of noise, congestion, and pollution.
From experience, people learn also that the bicycle is a very efficient means of transport for a lot of trips and trip purposes.
That is why consultations with the community about the living conditions of their cities and villages, are the right platform to discuss the value of cycling and to involve cycling in the planning for the future.
From a recent EU-survey involving car drivers from 17 European countries, it became clear that even car drivers think that cycling together with public transport and walking should get the highest priority in planning for the future (Cauzard and Wittink, 1998)

8.4. Set realistic targets

Target setting is a good way to make an inventory of what has to be done to plan for the future we wish to have. It makes clear what kind of sources we need to bring in, what kind of tools we need to make a good planning, and it also directs our activities to look for an effective and efficient approach. To replace car use, there is a need to combine measures for car reduction with measures to promote cycling, and to use money that is taxed on car use for planning for the bicycle. Facilities can be of a various kind to provide for a good bicycle climate.

The National Cycling Strategy (NCS) of the UK has as its central target, to double the number of trips by bicycle (on 1996 figures) by the end of 2002, and quadruple the number of trips by bicycle (on 1996 figures) by the end of 2012. Denmark’s national target is to increase the bicycle’s share of trips in urban areas by 4% by 2005, backed up by traffic funds. Finland has a target to double cycle use from 1993 to 2005 and halve accidents from 1993 to 2000 and they expect considerable socio-economic savings (Finnish Ministry of Transport, 1993).

The Dutch Bicycle Master Plan showed that national targets and a national strategy for cycling may 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 because of measures taken for the needs of cycle 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 fully active than before, regarding cycle traffic needs, medium sized authorities (to 135,000 inhabitants) and large authorities are both trying hard to restrict car use in combination with measures for cyclists (Dutch Ministry of Transport, 1998).

8.5. Create a good bicycle climate

There are a lot of possibilities to make cycling easier and to show cyclists that they are taken seriously.

The city of Ferrara, in Italy, provides visiting cyclists with a ‘bicicard’ which gives the holder reductions on museum entrance, restaurants, and hotels. In addition some of the city garages provide cycles to those whose cars are being repaired. Several cities across Europe now provide a ‘city-bike’, a free or low-cost bike for rental to those visiting the city.

Bicycles and public transport should be planned complementary, not competitive. A German study has found that the catchment area of a station reached by foot is increased 15 times if you take into account the wider area that people can cycle from. Which rail operator would not like a 1,500% rise in potential market for their services for the price of providing good quality cycle access, cycle parking at stations, and a programme of encouragement? This one factor could well justify the economic costs to place new rail stations closer to residential areas when they are being planned, or building rail lines further out into country areas, and the overall viability of suburban rail stations. In the Netherlands, some 45% of all rail passengers arrive at the station by bicycle.

Fiscal rewards can be developed for those adopting sustainable modes of transport. In the Netherlands in 1995, the Ministry of Finance started a scheme that allows an employer to give their employees bicycles. They pay less company tax and the employee pays no income tax on this ‘gift’. In addition, the costs of clothing, locks, and maintenance will qualify for tax relief. The employer has to ‘reasonably’ ensure that the bicycle is used for commuting, although the use of public transport or Park-and-Ride for part of the trip is allowed.

Promotion and education programmes have a great value in highlighting the advantages of cycling and prepare people for it. E.g. in the Netherlands there is a wide variety of cycle education programmes, for school children, for elderly people, for Turkish woman, and for mentally handicapped people.

8.6. Create good governance and structures

While it is true that cycling is the classic example of a policy that has to be decided at the most local level, and that ‘subsidiary’ should rule, this thinking has limited the progress for cycling. Of course the best level for decisions on routing and the precise provision of cycle facilities should be the local one. However, local government needs an overall framework within which their policies, priorities, and programmes fit.

The right structures within government and other responsible bodies must exist in order to deliver the policies. There is no point if different departments are not working in the same

direction. For example, it has sometimes been the case that while environment ministries have been keen to support pro-cycling policies, transport ministries have had other objectives, bringing the two policies into conflict. In this situation progress for cycling is very difficult.
At the wider level, and as recent pronouncements on transport policies show, it is also important that at the European level, both the Commissions and the Parliament have a clearly stated and co-ordinated policy to support cycling. Taken even wider, the policies of the various UN bodies and international treaties, can also be influential. For example, the bicycle can very clearly play a useful role in meeting the international targets on climate change, agreed at Kyoto in 1997. Local government must provide the local experience, while the national and international level must set the priorities and provide leadership. In that sense, cycling must work from the bottom-up and the top-down at the same time.

At the city level, Dublin is a good example of co-ordination. It has set up a transportation office to bring together the work of the seven local authorities in the area, promoting public transport and bicycles in particular (Kelly, 1997).

To show that cycling needs investments, and to show that car use in cities has to be reduced, cities may use taxes from car drivers for investments in bicycle facilities.
The Norwegian cities of Oslo and Trondheim are raising money by road-toll charges with more than £10 million going into cycle facilities in the latter city alone (Vodahl and Jolsgard, 1997). The city of Utrecht in the Netherlands is investing money they receive form car parking fees, into bicycle parking facilities.

8.7. Train professionals

Development of expertise and training is an important condition to design effective policies, in both government and the private sector.
If there is to be a sustained increase in levels of cycling, three aspects need to be addressed with some urgency.
Firstly, to make sure that those coming into the profession, fully appreciate both the policy needs and all the practical necessities of planning for cycle travel.
Secondly, to ensure that those already in the profession, maintain their skill levels and keep abreast of the latest developments. A working career can last 40 years, and in the fast-developing world of cycling, 'best practise' 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. Training plays a part in achieving this, in that if professional qualifications are fully developed and well recognised, it will help to persuade those entering the profession that it is a good career move.
Between 1990 and 1997, the Dutch Bicycle Master Plan has generated a wealth of knowledge and has disseminated this know-how and these experiences, at home and abroad. In this plan 112 surveys were carried out. Among these were 31 research projects, 41 demonstration projects, 18 projects for instrument development, and 22 plans for disseminating information (Dutch Ministry of Transport, 1998).
Another good way of capacity building is to exchange expertise and experiences between cities. Examples regarding cycling are, in Europe, the Car-Free Cities network and the Cities for Cyclists network. The World Health Organisation started the "Healthy Cities" network, and this network is also putting cycling high on the agenda. In France there is a national cycle-friendly towns club with more than 250 members.

8.8. Monitor success and failures

Setting targets and planning can not be fruitful without monitoring success and failures.
Target setting works the best when the targets are specified, from levels of cycle use and safety into its share of trips for several motives, use of connections, prevention of theft, use of parking facilities, accident involvement of different groups of users, type of accidents and injuries, actors that have to be involved, their level of involvement, and their activities etc.
Monitoring is an instrument to adapt policies when they are not as effective as foreseen, to remain flexible because external factors may change, and also to keep all actors alert and involved. Showing progress is of course a very important stimulus for the continuation of a cycling policy.

8.9. A structure for implementation conditions

With reference to the results of the Dutch Bicycle Master Plan at local government level (AVV, 1997), the following key factors for success and failure of a local bicycle policy have been presented:

a. Tradition in bicycle policies: the progress a local government can make in the near future depends very much on what has been achieved. This looks obvious, but it stresses the need to approach the development of measures for the cyclists as a process of creating different conditions.
b. Perception of local traffic problems: the need to control traffic better, opportunities to reach aims for e.g. mobility, the environment, the liveability of cities and villages by developing bicycle-policy.
c. Involvement of pressure groups.
d. Political willpower is the outcome of b. and c.; also the tradition and personnel capacity will influence the political will.
e. Personnel capacity: this means quality and enthusiasm within the local government organisation; this not only influences political willpower, but also the level of integration of bicycle policy in the overall policies.
f. Acknowledgement in the organisation of the need for a bicycle policy and services also influence the integration of bicycle policy in overall policies as well as implementation project budgets, together with the political will-power.
g. Integration of bicycle policy in overall policies is also influenced by pressure groups and external political support.
h. Project realisation is dependent from policy documents and project budgets.

To support an implementation strategy, expertise is important to:
1. support a good perception of problems and opportunities for reaching political aims,
2. support capacity building to transform this into policy documents.

8.10. Summary

This chapter described some main elements of an implementation strategy for the promotion of safe cycling. Although the context in Europe is very different, and the best steps to be taken are very dependent from national and local situations, the examples show that all across Europe initiatives have been taken and that a process is going on for a more and more structural approach of cycling.
Authorities at different levels have different kind of contributions. Taking into account the subsidiary principle, it is however very important that at the national and international level, strategies, instruments, capacity building, and dissemination of information, are organised. Planning for cycling will be most efficient when it is integrated in different kinds of policies, in transport, environment, land-use, health, economy and finances.
Project realisation needs political will, expertise, and organisation in order to develop policy plans and to reserve budgets, taking into account the tradition in bicycle policies.

To conclude, there are many ways to make steps towards a more bicycle-friendly climate, and local conditions should indicate what the best step is to be taken. But progress is dependent of a combination of knowing what is effective, how to plan and organise this, and of involvement and political will.

REFERENCES

AVV (1997). *Gemeentelijk Fietsbeleid; stand van zaken*. The Netherlands Transport Research Centre AVV, Dutch Ministry of Transport, Public Works and Water Management, Rotterdam, the Netherlands (In Dutch).

BASt (1997). *Vergleich des Verkehrsordnungsrechts in Europe; 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).

BIS-SWOV (1999). *Beleidsinformatiesysteem* (Policy information system). Data bank at SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Blokpoel, A. (1990). *Evaluatie van het effect op de verkeersonveiligheid van de invoering van zijreflectie bij fietsen.* R-90-04. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands (In Dutch).

Brög, W. and Erl, E. (1994). *Les transports mécanisés à courte distance. Importance du trafic non motorisé pour la mobilité dans nos villes*, Les déplacements à courte distance, 96ème table-ronde d'économie des transports, CEMT, Paris, OCDE, pp. 5-69 (In French).

Brög, W. (1995). Paper to Velo Regio conference in Troisdorf, 1995. Social Data München, Germany.

Brüde, U. and Larsson, J. (1996). *The safety of cyclist at roundabouts: a comparison between Swedish, Danish and Dutch results*. Swedish National Road and Traffic Research Institute VTI, Linköping, Sweden.

Carré J.-R. (1995). *La bicyclette: un mode de déplacement méconnu dans ses risques comme dans son usage*. In: Recherche, Transport, Sécurité, No. 49, pp.19-34 (In French).

Carré J.-R. et al. (1998). *Mobilité urbaine et déplacements non-motorisés : situation actuelle, évolutions, pratiques et choix modal. Volume I. Analyses statistiques et pistes de recherche sur la mobilité à pied et à bicyclette*, INRETS, Paris, France (In French).

Carré J.-R. et al. (1998). *Mobilité urbaine et déplacements non-motorisés : situation actuelle, évolutions, pratiques et choix modal. Volume II. Partie 1: La sécurité des piétons et des cyclistes*. INRETS, Paris, France (In French).

Cauzard, J.-P. (INRETS) and Wittink, R.D.(SWOV) (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.

Club des Villes Cyclables (1997). Congrès annuel, 1997.

CROW (1993). *Sign up for the bike.* Design manual for a cycle-friendly infrastructure. Ede, the Netherlands.

DoE (1997). *Cycles and lorries*. Traffic advisory leaflet. Department of the Environment, Traffic Advisory Unit, London.

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

Dutch Ministry of Transport (1995*). Cities make room for cyclists,* Dutch Ministry of Transport, Public Works and Water Management, The Hague, the Netherlands.

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.

ECF (1997*). Transport demand of modes not covered in international transport statistics. Cycling. Final report*. European Cyclists' Federation, Brussels, Belgium.

ECF (1998). *Improving Bicycle Safety without making helmet-use compulsory.* European Cyclists' Federation, Brussels, Belgium.

Edwards G. (1998). *The development and promotion of measures for vulnerable road users with regard to mobility integrated with safety. Pedal cyclist*. Project report PR/SE/441/98, contribution to Promising, TRL Transport Research Laboratory, Crowthorne, Great Britain.

Elvik, R., Mysen, A.B. and 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).

Finnish Ministry of Transport (1993). *Finland Moving on Two Wheels*. Finnish Ministry of Transport, Helsinki, Finland.

Hansen, F. (1995). *Cyclists' safety in Europe: a comparison between selected European studies.* Danish Council for Road Safety Research RfT, Gentofte, Denmark.

Herrstedt, L., Aakjer Nielsen, M., Agústsson, L., Lei, K.M., Jörgensen, E., and Jörgensen, N.O. (1994). *Cyklisters sikkerhed i byer*. (The safety of cyclists in urban areas.) Report 10. The Danish Road Directorate, Copenhagen, Denmark (In Danish).

Hydén, C. and Várhely, A. (2000). *The effects on safety, time consumption and environment of large scale use of roundabouts in an urban area: a case study*. Accident Analysis & Prevention. Vol. 21,
No. 1, pp. 11-23.

Joelsgard, E.J. and Vodahl, S.B. (1997). *The bicycle system of Trondheim, Norway*. In: Proceedings of the 10th international bicycle planning conference, Barcelona, 15-19 September 1997. Ajuntament de Barcelona / AproB, Amics de la Bici / European Cyclists' Federation, Brussels.

Kelly, R. (1997). *Dublin. A rejuvenated city – DTI brings back the bicycle*. In: Proceedings of the 10th international bicycle planning conference, Barcelona, 15-19 September 1997. Ajuntament de Barcelona / AproB, Amics de la Bici / European Cyclists' Federation, Brussels.

Koivurova, M. and Valtonen, J. (1987). *Autojen ohitusetäisyys polkupyöräilijästä* (Motorists' overtaking distance to cyclists). Liikenneturvan tutkimuksia 88/1987. (In Finnish.)

Knight, I (1998). *A review of TRL research concerning the protection offered to unprotected road users by HGV Sideguards.* TRL Transport Research Laboratory, Crowthorne, Great Britain.

Leden, L. (1989). *The safety of cycling children: effect of the street environment*, VTT Publications, E55. Technical Research Centre of Finland VTT, Espoo, Finland.

Leden, L. (1998). *Pedestrian risk decrease with pedestrian flow and increase with vehicle flow - A case study*. In: Proceedings of the 10th workshop of the International Co-operation on Theories and Concepts in Traffic Safety (ICTCT) 5-7 November 1997. Lund. ICTCT Secretariat ,Vienna / Lund University, Department of Traffic Planning and Engineering, Lund, Sweden.

Leden, L., Gårder, G., and Pulkkinen, U. (1998). *Measuring the safety effect of raised bicycle crossings using a new research methodology*. Paper No 98-1360 presented at the 77th annual meeting of the Transportation Research Board TRB, Washington, D.C., January 11-15 1998. Washington D.C., USA.

Leden, L. and Wramborg, P. (1999). *A safe non-restrictive cycle network*. Proceedings from the Finnish Promising National Forum, 1-8 April 1999, Helsinki. Technical Research Centre of Finland VTT, Espoo, Finland.

Linderholm, L. (1992). *Traffic safety evaluation of engineering measures - Development of a method and its application to how physical lay-outs influence bicyclists at signalised intersections*. Department of Traffic Planning and Engineering LTH. Lund, Sweden.

Myllylä, M. (1995). In: Proceedings of the 8th Velo City Conference, Basel, 26-30 September 1995. Interessengemeinschaft IG Velo, Basel, Switzerland / European Cyclists' Federation, Brussels, Belgium.

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

Pibault, C. and Bilman, G. (1996). *Les accidents corporels des cyclistes à Paris. Année 1995*. Centre de recherche et d'études techniques, Mairie de Paris, France (In French).

Rantatalo, O. and Wikström, P.-E. (1998). *Utformning och implementering av trafiklugnande åtgärder i tätortsmiljö* (Design and implementation of traffic calming measures in urban areas). Examensarbete 1998:263 CIV. Luleå Technical University, Sweden (In Swedish).

Räsänen, M. and Summala, H. (1998*). Attention and expectation problems in bicycle-car collisions: an in-depth study*. Accident Analysis and Prevention. Vol. 30, No. 5, pp. 657-666.

Schoon, C.C. (1996a). *Invloed kwaliteit fiets op ongevallen; ; Een ongevallenanalyse aan de hand van een schriftelijke enquête.* R-96-32. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands (In Dutch).

Schoon, C.C. (1996b). *Praktijkonderzoek zijafscherming voor vrachtauto's; Een demonstratieproject gericht op praktijk, brandstofbesparing en veiligheid*. R-96-24. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands (In Dutch).

Schoon, C.C. and Polak, P.H. (1998). *Normen en eisen voor fietsverlichting en -accessoires en de kosteneffectiviteit van de witte voor-reflector*; R-98-25. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands (In Dutch).

Schoon, C.C. and Varkevisser, G.A. (1996). *Het voeren van verlichting door fietsers, brom- en snorfietsers*. R-96-39. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands (In Dutch).

Sharples, R. (1999). The use of main roads by utility cyclists in urban areas. Traffic Engineering and Control. 1999, No. 1, pp. 18-22.

Summala, H., Pasanen, E., Räsänen, M. & Sievänen, J. (1996). *Bicycle accidents and drivers' visual search at left and right turns. Accident Analysis & Prevention.* Vol. 28, No. 2, pp. 147-153.

SWOV (1992). *Naar een duurzaam veilig wegverkeer* (Towards a sustainably safe road system). SWOV Institute for Road Safety Research, Leidschendam, the Netherlands (In Dutch).

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.

Wramborg, P. (1998). *On a new approach to traffic planning and street design in Sweden*. Bahrain, SORIC – 98. Reprint from the proceedings of the 4th international conference on Safety and the Environment in the 21st century, 23-27 November 1997, Tel Aviv, Israel.

APPENDIX:
NON-RESTRICTIVE MEASURES PROMOTING SAFETY AND MOBILITY

A broad range of measures that may affect safety and mobility for bicyclists has been surveyed. The aim has been to find non-restrictive measures that promote safety and mobility. One reason for this approach is that there is evidence that an increase in pedestrian and cycle flow will lead to reduced risk per pedestrian and cyclist; see Leden, Gårder and Pulkkinen (1998), and Leden (1997). A preliminary list of relevant measures was given in the proposal. This list was revised and updated, mainly based on results from the reviewing of literature. Altogether 29 countermeasures were listed. To judge if a measure is non-restrictive or not a criteria was developed.

Relevant measures were listed and grouped in the following categories: Infrastructure, crossing design, injury protection, cycle requirements, cycle training, and various.
One of the members of the WP2 group, Tom Goodefroij, assessed the restrictiveness of the listed measures, see last column of Table A.1. The Finnish National Road Administration and the city of Malmö kindly provided with estimates of construction and maintenance costs for some of the countermeasures.
The measures were ranked according to their estimated effect on safety and mobility in Table A.1.
If two measures got the same score, we ranked the countermeasure having better effect on safety as being higher than the other one.

The effect on safety and mobility of the countermeasures will be commented below.

Infrastructure

The countermeasures will be commented on below in ranking order.

1. Highest rank has *spatial proximity*. It is an essential precondition for extensive bicycle use.

2. Second highest ranking has *cycle streets*, streets where bicyclists have priority over motor vehicles and motor vehicles cross cycle streets at walking speeds. Cycle streets increase safety for cyclists significantly, see *e.g.* Leden (1989).

3. *Significant short cuts by grade separated crossings*. The word 'short cut' would imply a non-restrictive character of such facility. As a matter of fact, many grade separated crossings, with typical designs today, cause detours. Another restrictive element of such a facility can be the gradient. Overall, the value of a short cut is very much dependent of the quality of the design.

4. *Safer choice of route* could have a significant safety effect. However, the actual choice is dependent on access to destination, route knowledge, perceived distance and time, ease of travel, safety, comfort and experience (Sharples, 1999). The word 'choice' would imply the non-restrictive character of such measure. However, the safer route should also meet the other quality requirements (directness, comfort, coherence, and attractiveness). This is even more the case if the use of less safe routes is discouraged or even forbidden.

5. *Cycle-tracks*. If junction design complies with ‘best practise’, the safety effect is significant. If not safety deteriorate. It should be stated that cycle tracks (if well designed; see above) are an excellent solution for heavy trafficked roads. Cycle tracks can be restrictive if

not properly designed or when applied in wrong situations. The width is a very important element in this respect. It should allow for the flow of the actual number of users at peak hours, giving room for overtaking manoeuvres. Also a smooth alignment and a smooth pavement is important in this respect. Bicycle tracks might be less appropriate alongside roads with many individual destination addresses. Physically segregated bicycle tracks hamper the crossing possibilities.

6. “Building *missing links”* is not restrictive and have a potential to increase safety for cyclists.

7. Provided that *cycle lanes* are applied in the right conditions (see Sign up for the bike), it is a non-restrictive measure. An improper application of bicycle lanes is a different story.

8. *Other significant short cuts* than grade-separated crossings are, in principle, not restrictive.

9. *Green ways* improve safety significant as conflicts with motor traffic are avoided. Whether providing green ways would be restrictive is very much depending on circumstances. If such green ways result in detours and less priority at crossings, that might be restrictive. Another restrictive element of green ways could be their rather isolated environment with a lack of social supervision. People, especially women, might feel insecure because of that. On the other hand, green ways can also be very attractive and the opposite of restrictive, if it is well designed and well used.

10. *Road lighting* will help cyclists to see their way, improves visibility and safety. A potential disadvantage is that it will keep cyclists from using their bicycle lights. Overall the balance is positive. In any case this is not a restrictive measure.

11. *Contra flow cycle lanes* are not restrictive.

12. *To have one-way cycle traffic* has a significant safety effect as driver expectations are met. Such a measure needs to be judged in the specific situation where it is applied. On the one hand, allowing the use of bicycle paths in two directions might prevent detours and take away the necessity for crossing the main road. On the other hand, two-directional bicycle paths create difficulties at intersections. This could either result in more accidents, or in a more complicated design of the intersection. Avoiding two-directional use of bicycle paths could be a good safety measure. It will mainly depend on its position in the whole bicycle route network whether such measure will result in detours, extra need for crossing roads, and such.

Crossing design

The countermeasures are commented on below in ranking order.

1. *Speed-reducing devices* have a restrictive character by their very nature: They are designed to restrict speed. If well designed, the discomfort for cyclists should be minimised. In practice this is not always the case. Many humps on a main bicycle route will be experienced as very uncomfortable, and therefore restrictive. If cyclists can use a bypass, they can avoid the restrictive experience of the humps. If the speed-reducing device is not a hump, but a chicane or a narrowing, it is important to prevent cyclists being jammed. A bypass for cyclist might take away the restrictive aspects of such devices. For traffic calming in general it should be stated that the balance between positive and negative effects must be monitored. However,

speed-reducing devices improve interaction and safety, and may also be an efficient mean to adjust motor traffic flows to desired levels.

2. *Refuges in crossings:* lower vehicle speeds, increase feelings of mutual respect and improves safety for cyclists if well designed, and is in principle non-restrictive, unless it forces cyclists to make difficult steering manoeuvres. The presence of such refuges must not be an alibi for not giving priority to cyclists.

3. *Raised crossings* increase interaction and safety for cyclists but may create some discomfort for cyclists as well. As long as this discomfort is more severe for motor traffic, the overall balance is positive

4. In principle, advanced stop lines give more options to cyclists. Non-restrictive.

5. *Mini roundabouts.* If properly designed, mini roundabouts increase feelings of mutual respect and cyclists' safety, see Chapter 4. Whether roundabouts are a restrictive feature for cyclists is very much dependent on the design. Important features are:
- The speed-reducing effect of the roundabout design;
- The priority at point of entry;
- Whether the cyclists are mixed, have a separate lane, or a bicycle path around the roundabout;
- The priority situation for cyclists.

Subtle differences in design may result in very different subjective experiences as well as different objective delays and levels of safety. An assessment of the restrictiveness of roundabouts can therefore be given only for specific situations.

6. *Blue cycle crossings* at signalized intersections are a typical Scandinavian design. Important is the visual indication of where cyclists can be expected, which has a significant safety effect. A restrictive element could be the implication that at such intersections, a direct left turn is forbidden. This limits the freedom of movement of cyclists and enlarges the travel time over the intersection.

7. *Truncated cycle paths* can contribute positively to the visibility of cyclists and increase interaction and safety for cyclists significantly (Herrstedt, Nielsen and Agústsson, 1994). It gives cyclists a certain freedom of movement on the crossing. A drawback of this measure could be that a safe refuge to oversee the situation is not available. For children and elderly this might be a restrictive circumstance.

8. *Simple marked crossings with white rectangles.* The marking as such is not restrictive. Whether this is a good solution is very much dependent of the total layout of the intersection.

9. *Warning sign for two directional cycle traffic.* As cyclists from the unexpected direction are much more at risk than those from the 'right' direction, it is worthwhile to raise the alertness of car drivers towards these cyclists. If this measure indeed creates a better understanding of the traffic situation, this would be an alternative for the more restrictive approach which now often is applied. (The problem that car drivers do not detect cyclists, who should have the right of way, is simply solved by taking away priority from the cyclists.) The main question is, however, whether the proposed warning sign is sufficient to be effective.

Injury protection

The countermeasures are commented on below in ranking order.

1. *Soft bumpers* on cars, side impact protection (*sideguards*) for trucks, etc. are not restrictive for cyclists, but will probably not have a positive effect on modal shift to cycling. As concluded in Chapter 4, sideguards have a significant safety effect.

2. *Helmet use - free choice* Helmets reduce the severity of head injuries significantly. However helmets might be uncomfortable. Moreover, helmet use creates an image of cycling as being disproportionally dangerous. Therefore promotion of voluntary helmet use still should be considered as a restrictive measure. Also, a person who for some reason does not have access to a helmet, may refrain from riding a cycle at that time if helmets are thought of as essential for safety.

3. *Helmet use – obligations*. This measure has proven to be very restrictive. In Australia it has resulted in a decrease of bicycle use of about 35%. In that way the measure is totally counterproductive. Positive health effects of cycling (prevention of untimely death because of heart and coronary diseases and such) outweigh by far the negative health effects of dangerous road conditions.

Cycle requirements

The countermeasures are commented on below in ranking order.

1. *Reflectors and lights on cycles* have a significant safety effect. An obligation to have reflectors is in principle not restrictive. The same should be true with regards to lighting equipment, but unfortunately it is not that simple. Dynamo systems require more labour effort from cyclists, and battery systems need a very careful monitoring of the battery conditions, and regular costs for their replacement. In practice bicycle lighting systems are not very reliable either. In fact one can argue that the unreliability of lighting systems are restrictive for cycling. A non-restrictive measure in this field would be to create legal standards requiring a more reliable and solid quality of bicycle lights. The sale of below-standard equipment should consequently be forbidden.

2. *Brakes on both wheels compared to rear-wheel brake only* has a significant safety effect. If only imposed on new bicycles, this is a non-restrictive measure. However, maintenance of brakes may be somewhat of a restriction if quality isn't high.

3. *Lateral distance spacers on bikes (red flags etc.)* have a limited positive safety effect, and a limited restrictive effect on mobility. The positive effect is very much dependant on the traffic environment, and can be expected only on roads for shared use. On such roads, the use of spacers may result in wider overtaking manoeuvres by motorised road users. On the other hand, such spacers require more clearing space for cyclists and restrict them in using narrow 'openings' in urban traffic situations.

Cycle training

As long as cycle training is not mandatory, this would be a non-restrictive measure. A final assessment, however, should take into account the content of such a training programme. The result should be: higher confidence in riding a bicycle and better interaction with other road users.

Various

The countermeasures are commented on below in ranking order.

1. *Facilities for showering* could take away some quoted impediments not cycling. Not restrictive at all. Limited positive effect on bicycle use.

2. *Cycle racks*. Good bicycle parking facilities enlarge the possibilities for bicycle use considerably.

Table A.1. *Costs and restrictiveness of countermeasures, ranked according to their estimated effect on safety and mobility. (10 SEK = 1 ECU; 6 FIM = 1 ECU).*

List of measures	**Construction (costs)**	**Maintenance (costs per year)**	**Restrictiveness**
INFRASTRUCTURE			
1. Spatial proximity	700 SEK/m	15 SEK/m	Not restrictive
2. Cycle streets			Not restrictive
3. Significant shortcuts by grade separated crossings	Tunnel 700,000 FIM Bridge 900,000 FIM		Not restrictive (if properly designed)
4. Safer choice of route			Not restrictive (if not mandatory)
5. Cycle tracks	1500 SEK/m 0.4-1.5 MFIM/km		Can be restrictive if not properly designed
6. Missing links			Not restrictive
7. Cycle lanes	40 SEK/m	20 SEK/m	Not restrictive (in right condition)
8. Other significant short cuts than grade separated crossings			In principle not restrictive
9. Green ways	200 SEK/m		In principle not restrictive
10. Road lighting	Iron posts 210-260,000 FIM Wooden posts 90-110,000 FIM	6,000-10,000 FIM	Not restrictive
11. Contra flow cycle lanes (Cycle lanes going the “wrong” way on one-way streets)	2,000 SEK/m		Not restrictive
12. To have one-way cycle traffic			

Table A.1. (Continued).

List of measures	**Construction (costs)**	**Maintenance (costs per year)**	**Restrictiveness**
CROSSING DESIGN			
1. Speed reducing devices	2,000 SEK/m		Depends of design
2. Refuges in crossings	10,000 SEK		In principle not restrictive
3. Raised crossings	150,000 SEK		Not restrictive if correctly designed
4. Advanced stop lines	40 SEK/m	20 SEK/m	Not restrictive
5. Mini roundabouts	750,000 SEK		Depends of design
6. Blue cycle crossings at signalized intersections	110 SEK/m^2	55 SEK/m^2	In principle not restrictive
7. Truncated cycle paths	40 SEK/m	20 SEK/m	Might be restrictive for children
8. Simple marked crossings with white rectangles	70 SEK/m	35 SEK/m	Not restrictive
9. Warning sign for two directional cycle traffic	1,200 SEK/piece		Not restrictive
INJURY PROTECTIONS			
1. Soft bumpers etc. on cars			Not restrictive
2. Helmet use - free choice			Somewhat restrictive
3. Helmet use – obligations			Restrictive
CYCLE REQUIREMENTS			
1. Reflectors and lights on cycles			In principle not restrictive
2. Brakes on both wheels compared to rear wheel only			Not restrictive (if imposed on new bicycles)
3. Lateral distance spacers on bikes (red flags etc)			Limited restrictive
CYCLE TRAINING			Not restrictive (if not mandatory) and may make bicyclists dare to ride in new environments
VARIOUS			
1. Facilities for showering			Not restrictive
2. Cycle racks	700 SEK/location	0 SEK	Not restrictive