Safety of Pedestrians and Cyclists in Urban Areas

Brussels 1999

European Transport Safety Council
Rue du Cornet 34
B – 1040

Tel: 0032 2 230 4106
Fax: 0032 2 230 4215
email: info@etsc.be

ISBN: 90-76024-08-1

Acknowledgements

ETSC gratefully acknowledges the contributions of members of ETSC's Pedestrian and Pedal Cyclist Safety Working Party to this review:

Working Party Members

Dr. Rudolf Günther (Chairman)
Dr. Lars Ekman
Ir. Edgar Janssen
Mr. Derek Palmer
Mr. Antonio Lemonde De Macedo
Prof. Richard Allsop
Dr. Lene Herrstedt
Dr. Christa Michalik
Mr. Dominique Fleury

ETSC Staff

Mrs Jeanne Breen
Ms. Marie Ward

ETSC is grateful for the financial support provided by DGVII of the European Commission and for the contribution towards the printing and dissemination costs of this review provided by 3M Europe, BP Amoco and KeyMed. The contents of this review are the sole responsibility of ETSC and do not necessarily reflect the view of sponsors nor organisations to which research staff participating in the Working Party belong.

The European Transport Safety Council

The European Transport Safety Council (ETSC) is an international non-governmental organisation which was formed in 1993 in response to the persistent and unacceptably high European road casualty toll and public concern about individual transport tragedies. Cutting across national and sectoral interests, ETSC provides an impartial source of advice on transport safety matters to the European Commission, the European Parliament and, where appropriate, to national governments and organisations concerned with safety throughout Europe.

The Council brings together experts of international reputation on its Working Parties, and representatives of a wide range of national and international organisations with transport safety interests and Parliamentarians of all parties on its Main Council to exchange experience and knowledge and to identify and promote research-based contributions to transport safety.

CONTENTS PAGE

Executive Summary

Introduction

As part of ETSC's current programme which receives matched funding from the European Commission, the European Transport Safety Council has brought together independent experts from across the EU to carry out a multi-disciplinary review of pedestrian and pedal cyclist safety in urban areas. The aim is to identify the key problems which need to be addressed and successful practice internationally in implementing effective measures. Recommendations are made for appropriate actions locally, nationally and by the EU for the short to medium term.

The casualty problem

In 1996 more than 9,400 pedestrians and cyclists were killed in EU countries, contributing around 22 per cent of all road deaths. The small proportion of pedestrian and cyclist casualties that occur in rural areas are relatively severe and should not be forgotten, but this review is concerned with the great majority that occur in urban areas.
The per capita risk of death from walking and cycling in EU countries are shown in Table 1 (p.15). These figures represent the per capita risk of the activity without taking any account of the level of the activity. To obtain a better understanding of the risk to both pedestrians and cyclists, each country needs to collect information on the amount of walking and cycling.

The overall long term trend in deaths has been downward for both pedestrians and cyclists, but this may be due in some instances to a decline in walking and cycling as more people take to their cars for local journeys. However, this trend may be influenced in future by the encouragement now being given in several Member States to travel by foot, bicycle or public transport. For example, the Danish National Traffic Plan states that 4 per cent of total car traffic should be converted into cycling and walking by the year 2005 and one-third of all car traffic under 3 km into non-motorised travel. As travel by public transport is also encouraged, increasing account needs to be taken of the safety of walking or cycling to catch the bus, tram or train. Walking and cycling have much greater risk levels per hour than travel in public transport vehicles.

It should therefore be a high priority for those responsible for traffic systems in our urban areas to cater much better for the needs and physical vulnerabilities of pedestrians and cyclists, including people with reduced mobility. There are many ways in which the EU can help them to do so.

Key problems for pedestrians and cyclists in today's traffic system

Most road safety problems for pedestrians and cyclists are common to all Member States. These result from a complex mix of factors, but underlying all other problems is the fact that the modern traffic system is designed largely from a car-user perspective. There has been a lack of coherent planning of route networks for pedestrians and cyclists.

Vulnerability Even at relatively low impact speed, pedestrians and cyclists receive severe injuries, mainly because their only protection is their clothing. Speed plays an important role in determining the severity of the outcome of collisions. If the collision speed exceeds 45 km/h the likelihood for a pedestrian or cyclist to survive the crash is less than 50 per cent. If the collision speed is less than 30 km/h more than 90 per cent of those struck survive. Speed management, therefore, is a key element in a safe traffic system for vulnerable road users.

Flexibility Pedestrians and cyclists are very flexible in their behaviour and flexibility is one of the main advantages of these modes. In relation to other road users, however, this presents a problem. A motor vehicle driver can never be sure when or where to expect a pedestrian or a cyclist.

Instability Pedestrians and especially cyclists may trip or fall in the traffic environment. A small mistake or a minor failure of the cycle may result in a severe outcome even though there are no other road users present. A pedestrian may stumble and receive serious injuries just because of an uneven surface. The instability of pedestrians and cyclists is an even bigger problem when they are mixed with motor traffic.

Invisibility Pedestrians and cyclists can be difficult to see: They are small compared to a car, and can be hidden by one. At night the problem is more severe.

Differing abilities Pedestrians and cyclists include children with lack of experience, elderly people with reduced capability, and people with reduced mobility.

Consciousness of effort Making a detour in a motor vehicle may use extra fuel, but for pedestrians and cyclists it means extra use of their muscles. They are therefore highly motivated to find and keep to the easiest routes, often the most direct ones.

Estrangement Pedestrians are often primarily doing other things than travelling on foot, like window shopping or chatting with friends. This, together with the fact that the modern traffic environment is often designed for cars rather than for pedestrians and cyclists, creates a state of estrangement of pedestrians and cyclists. Cyclists make journeys more often, but even they are frequently treated as intruders in the traffic system rather than as an integral part of that system.

These key problems need to be addressed in combination in future traffic system planning.

Key casualty reduction strategies

The key strategies for achieving a safe traffic system for pedestrians and cyclists are:

- Managing the traffic mix, by separating different kinds of road use to eliminate conflicts where conditions are favourable to separation.
- Creating safer conditions elsewhere for integrated use of road space, for example through speed and traffic management, increased user and vehicle conspicuity, and vehicle engineering and technology.
- Modifying the attitudes and behaviour of drivers of motor vehicles through information, training and the enforcement of traffic law.
- Consulting and informing pedestrians and cyclists about changes being made for their benefit, and encouraging them in steps that they can take to reduce their risk.
- Mitigating the consequences of crashes through crash protective design and encouraging the use of protective equipment.

And, to these ends

- Changing priorities in the minds of professionals and policymakers responsible for the traffic system through sharing of experience and promotion of research findings, and encouraging them to convince the public of the need for change.
- Separation and integration to make walking and cycling safer.

Comprehensive networks of pedestrian and cycle routes need to be identified which will consist of sections of footpath or cycle path separate from the carriageway, pedestrian areas, footways or cycle tracks alongside carriageways, and areas and carriageways shared with motor vehicles. Where separation can provide attractive routes, the safety benefits can be great: Danish studies, for example, show reductions of 35 per cent in cyclist casualties after the construction of cycle tracks alongside urban roads. But the scope for providing attractive routes by practicable separation for the journeys people really want to make on foot or bicycle is limited. Elsewhere it is necessary to create safer conditions for integrated use of shared road space through speed and traffic management, by increasing conspicuity, through vehicle engineering and collision-avoidance measures, and by influencing road user behaviour, as envisaged in the Dutch concept of sustainable safety.

Speed and traffic management Road safety engineering measures to create safer conditions for pedestrians and cyclists can be considered in terms of traffic reduction, speed reduction, junction treatments, the redistribution of road space and the creation of special facilities.

Motor traffic on local roads within cells formed by main roads can be reduced whilst creating good routes for walking and cycling through selective road closures and traffic calming, within a strategy of urban safety management. Area-wide schemes in Denmark, Germany, the Netherlands and the UK have reduced casualties in the treated areas and on surrounding main roads by between 15 and 80 per cent.

At speeds below 30 km/h, pedestrians and cyclists can mix with motor vehicles in relative safety, and in The Netherlands 30 km/h zones have reduced personal injury crashes by 22 per cent. As a contribution to sustainable safety, they are to be

extended to cover built-up areas in general in The Netherlands, with specific exceptions for selected roads only.

Junctions are places where many pedestrians need to cross the road despite the risks in doing so, and in Denmark, for example, over 60 per cent of crashes involving cyclists occur at junctions. Good layout and sharing of the road space with the help of signs, markings and distinctive surfacing can simplify the tasks facing pedestrians and cyclists at junctions and thus reduce casualties there. Sharing of the road space between junctions is also important – not only cycle lanes, but also correct use of bus lanes and allocation of more of the width to nearside lanes on multilane roads used by cyclists.

Increased conspicuity The more conspicuous motor vehicles are to road users outside them, and the latter are to drivers, the more opportunity both will have to avoid collisions. Road layout can help in this and so can the use of daytime running lights by drivers, the use of lights at night by cyclists, and the wearing of reflective or light-coloured clothing by pedestrians and cyclists.

Vehicle engineering and technology Intelligent speed limiters, intelligent cruise control, collision-avoidance systems and vision enhancement for drivers are all forms of technology for the motor vehicle that could reduce the occurrence of collisions with pedestrians and cyclists - and better vehicle design could reduce the severity of injury to them in collisions that still occur. Better design and maintenance of cycles, helped by European Standards, could help to reduce not only such collisions but also the many injurious cycle crashes that involve no motor vehicle.

Modifying drivers' attitudes and behaviour

Training provided by driving instructors, the advice and information that drivers receive from user and safety organisations, and the influence exerted upon them by enforcement should all be reoriented to promote attitudes and behaviour based on higher priority for the safety of pedestrians and cyclists on the roads the drivers use. Emphasis should be placed both upon greater consideration and upon greater compliance with traffic laws concerning speed and giving way, whose effect on the safety of pedestrians and cyclists is strongest. Road users of all kinds would be helped in this by production of a European Highway Code summarising the common and differing traffic laws applying to road users in the various Member States.

Consulting and influencing pedestrians and cyclists

Achievement of safe routes for walking and cycling which are also attractive to their intended users will be helped by consultation with pedestrians, cyclists and prospective cyclists in the catchment areas of the routes, as well as research into the journeys they wish to make on foot or bicycle.

Even on the best practicable routes, safe walking and cycling calls for competence on the part of the pedestrians and cyclists. Information, education and training should therefore be provided for pedestrians, cyclists and potential cyclists of all ages from the nursery and kindergarten through the school years to young adulthood, and

later as parents and as middle-aged and elderly people adjusting to the changes in capability that come with advancing years.

Mitigating the consequences of crashes

The consequences of those crashes that still occur despite all the other measures should be mitigated by crash-protective vehicle design and encouraging the use of protective equipment. Since many pedestrian and cyclist collisions are with cars, major improvements in crash protection for both cyclists and pedestrians should be achieved by changing car design. EU-funded research over the last 20 years has developed safer car fronts for pedestrians and cyclists. Test procedures devised by the European Experimental Vehicles Committee (EEVC) and used in the EuroNCAP (new car assessment programme) are showing that new cars are not performing satisfactorily in this respect. A new EU Directive on safer car fronts for pedestrians and cyclists incorporating all the EEVC tests should, therefore, be implemented without delay to provide the necessary protection.

In the meantime, further EU funding is needed for the EuroNCAP consumer information programme, so that as many new cars as possible are subjected to these fairly expensive tests to encourage manufacturers to build in protection earlier than the Directive will require.

When heavy good vehicles and vulnerable road users are side by side and the vehicle turns in their direction, the pedestrian or cyclist is at risk of being run over by the vehicle. A mandatory EU requirement is needed for the fitment to all new heavy goods vehicles of sideguards that greatly reduce this risk.

However much is done to make motor vehicles less injurious to cyclists, the protection offered by cycle helmets remains crucial, not least because many head injuries to cyclists are sustained in crashes or falls that do not involve a motor vehicle. The injury-reducing effects of cycle helmets have been found to be in the region of 45–80 per cent and their use needs to be encouraged, particularly in the high-risk groups such as boys aged 10–14 years. The design of child seats can also affect the risk of injury to the young children carried in them, and a European standard for cycle child seats should therefore be developed.

Changing priorities in the minds of professionals and policymakers

Effective implementation of the foregoing range of measures for safer walking and cycling requires dedicated and technically informed effort by all of the many professionals involved, together with commitment by policymakers and the support of a convinced public.

This requires systematic dissemination of research-based interdisciplinary technical guidance that synthesises current best practice to town planners, architects, highway and traffic engineers, road safety professionals, the police and judiciary, driving instructors, teachers, those who work with parents and elderly people, and designers of vehicles and protective equipment. It also requires technically supported guidance in policy formulation to be communicated to policymakers, who in turn should be encouraged to join with road safety organisations and road user groups in

campaigns to inform the public and win their acceptance of the necessary policies and measures.

The need for further research

All these efforts can be started on the basis of present knowledge, but to maintain progress cost-effectively in the medium term requires:

- deeper understanding of the change that is needed and its implications;
- fuller quantification of the problem and of progress made in addressing it; and
- safer cycles and further techniques of crash protection for pedestrians and cyclists.

A range of specific topics for research in these three areas has been identified.

Conclusion

By implementing known countermeasures it should be possible to achieve considerable increases in the use of healthier and more environmentally friendly means of transport and still reduce the numbers of deaths and injuries among pedestrians and cyclists. Deep commitment is needed from policymakers at local, national and EU levels to bring about this positive scenario. The following actions are recommended at these three levels.

Recommendations

For action by Member States and Local Authorities
Give priority to the safety and convenience of walking and cycling in policymaking for planning, development and transport in urban areas, and in the implementation of development plans and the maintenance and enhancement of the transport and traffic systems of towns and cities.

For action by the EU

- Give priority to the safety and convenience of walking and cycling in all aspects of policymaking relevant to planning, development and transport in urban areas and encourage Member States and Local Authorities to do likewise.
- Encourage Member States to collect exposure data on pedestrian and cyclist travel and include it in the CARE database (Community databank on road crashes and casualties in Europe).
- Regularly ascertain level of under-reporting and extend the EHLAS (European home and leisure accident surveillance system) database to include road collision reporting.
- Encourage information exchange to promote better conditions for walking and cycling through development of EU technical guidelines for professionals particularly on:

- Ways of providing for walking and cycling
- Safety audit and safety impact assessment
- Urban safety management

- Speed management
- Low cost / high return road safety engineering measures
- Training and encouragement for drivers in helping the integration of pedestrians and cyclists into the traffic system
- Initial and in-service training in the integration of pedestrians and cyclists for those involved in road safety education and training, driver training and the enforcement of traffic law
- Road safety education and training at pre-school, primary, secondary and tertiary levels, emphasising activity as pedestrians and cyclists
- Education and training of elderly road users
- In-service training for professionals in providing facilities for walking and cycling

all in the context of the interdisciplinary approach that the task requires.

- Bring forward mandatory EU fitment requirements for:

- safer car fronts for pedestrians and cyclists incorporating EEVC test procedures
- closed sideguards on all new heavy goods vehicles
- daytime running lights for motor vehicles

- Give continued support including more financial support to Euro NCAP.
- Introduce EU Whole Vehicle Type Approval for cycles incorporating a range of technical safety criteria.
- Develop a European standard for cycle child seats and promote the use of cycle helmets for which a European standard (EN 1708) already exists.
- Develop and disseminate advice on sensible road use via a European Highway Code summarising the common and differing traffic laws applying to road users in different Member States.

1 Introduction

This review on the safety of pedestrians and cyclists in urban areas forms part of ETSC's general mission to define holistic strategies aiming at the improvement of road safety in EU countries and identifying specific proposals addressing key problem areas.

Results derived from quantitative and qualitative studies of the numbers and circumstances of crashes involving pedestrians and cyclists are outlined; the conceptual basis of strategies for countermeasures and their effective implementation, derived from research and experience in different EU countries, are presented; and finally wide-ranging recommendations are made.

Taking account of the valuable contributions on vulnerable road user safety made recently by the OECD, ECMT, and first reports on the EU projects, MASTER and PROMISING, this review offers additional information and insights to help to reduce the road crash risk of vulnerable road users in the European Union.

1.1 Crash risk

In 1996 more than 9,400 pedestrians and cyclists were killed in EU countries as a consequence of road crashes, contributing 22 per cent of all road deaths (IRTAD, 1999). The risk of being killed in traffic per kilometre travelled is more than four times higher for these two groups than for car occupants (ETSC, 1999a). The severity of injuries is higher than for car occupants. The average severity is generally higher in rural areas, but the great majority of casualties to pedestrians and cyclists occur in urban areas.

On average in EU countries, pedestrian and cycle crash risks are higher for children, young people and elderly road users. In particular, the risk of death in traffic for pedestrians aged 65 and older is four times higher than for young adults. There are notable differences between countries (for example, the proportion of fatalities who are cyclists is lowest in Greece, Portugal and Spain), probably partly explained by differences in amounts and patterns of walking and cycling. These, in turn, reflect economic, social, infrastructural, topographical and climatic conditions. More information is needed about levels of pedestrian and cyclist traffic in the EU before crash risk differences can be fully understood.

1.2 Broader societal perspectives

In considering the needs of pedestrians and cyclists, health, environmental and other social objectives are complementary to that of reducing the risk of injury on the roads.

Health dimension. In contrast to motorised travel, walking and cycling require physical effort and are, therefore, health-promoting. At all ages they are the most common and regular physical activity. Their benefits to public health are increasingly understood. As a result some Member States are introducing policies to

promote walking and cycling. For example, the Danish National Traffic Plan targets 4 per cent of total car traffic to be converted into cycling and walking by the year 2005 and one-third of all car journeys shorter than 3 km into non-motorised travel.

Environmental dimension. Motor traffic contributes significantly to urban environmental pollution. Traffic congestion, speed-reducing measures and the increasing availability of public transport mean that the time advantage of car travel compared with cycling or the combination of public transport, walking or cycling in urban areas has been reduced. A further environmental advantage of walking and cycling over car travel is that they require less parking space.

Social dimension. Provision for walking is essential to social interaction, not only because so many whole journeys and parts of so many journeys by public transport or private vehicle are made on foot, but also because people of all ages also use streets, pathways and pedestrian areas for a range of social activities such as talking to neighbours or playing outdoors.

Walking or cycling, together with public transport, provide the main means of getting about independently for a range of social groups including:

- children and young people who are not qualified to drive a car;
- adults accompanying smaller children;
- older people who are less able or less inclined to use the car;
- many wheelchair users; and
- people who are denied or choose not to have access to private motor vehicles.

As well as providing for ease of access and movement on foot and by cycle, planning and traffic management need to take into account that pedestrians and cyclists are particularly sensitive to pollution and crime which can deter walking and cycling. Improving the safety and attractiveness of urban areas for pedestrians and cyclists is important for the quality of urban living.

1.3 Conclusion

Many societal considerations indicate that cycling and walking (in combination with the use of public transport) should be encouraged, but this implies that high priority should be given to reducing risks to pedestrians and cyclists from motor traffic.

The integration of safety and other important societal goals – environmental protection, health promotion and improvement of social interaction – should lead to increased public and institutional support for traffic safety measures. The recent SARTRE survey (1998) of driving opinion in European countries indicates that improvements “for cyclists” and “of the public transport system” are already favoured by the majority of the EU drivers surveyed. This result suggests that improvements in alternatives to private motor transport find broad public acceptance in Europe.

This review sets out the challenge that providing for safer walking and cycling presents to policymakers and professionals concerned with the many relevant aspects of urban planning and design and of the road transport system and its use.

2 Pedestrian and cyclist casualties in EU Countries

Much of the epidemiological information presented here concerning the frequency, types and nature of the pedestrians and cyclist crashes is based on records of fatalities in the International Road Traffic Accident Database (IRTAD). Recording of fatalities is more comparable than that of other casualties. Interpretation is hindered by lack of data on amounts and kinds of walking and cycling.

2.1 General trends

In the EU as a whole in 1996, more than 9,400 pedestrians and cyclists were killed, almost 22 per cent of all road traffic deaths. Nearly three-quarters of these were pedestrians, and just over one-quarter cyclists.

As Table 1 shows, there are major differences between Member States, but these are difficult to interpret without comparable measures of exposure to risk in each country. For example, the relatively low numbers of cyclist fatalities in southern European countries may well reflect primarily their low levels of cycle use.

The long-term trend in deaths has been downward for both pedestrians and cyclists. Between 1980 and 1995, the pedestrian death rate per head for the EU as a whole fell by 30 per cent. The cyclist death rate shows a smaller reduction over the same period. Changes in exposure over time may also be important; some national studies show reduced average exposure times (for example of children walking), possibly indicating changes in patterns of mobility or outdoor activity.

Table 1: Numbers of pedestrians and pedal cyclists killed in relation to population and total road deaths in 14* EU-Countries in 1996

Coun-try	Pop. mill.	Number of deaths			Deaths per million population		Percentage of road deaths that were				
							Pedes-trians or cyclists in 1996	Pedestrians in		Cyclists in	
		All road users	Pedes-trians	Cyclists	Pedes-trians	Cyclists		1996	1980	1996	1980
A	8.01	1027	157	73	19.6	9.1	22.4	15.3	22.9	7.1	4.3
B	10.18	1356	155	120	15.2	11.8	20.3	11.4	21.2	8.8	10.1
D	81.90	8758	1178	594	14.4	7.3	20.2	13.5	24.7	6.8	8.9
DK	5.29	514	68	88	12.9	16.6	30.4	13.2	20.0	17.1	12.2
E	39.68	5483	960	102	24.2	2.6	19.4	17.5	23.2	1.9	1.9
F	58.21	8541	1043	317	17.9	5.4	15.9	12.2	17.6	3.7	5.3
FIN	5.13	404	70	46	13.6	9.0	28.7	17.3	25.2	11.4	19.4
GR	10.48	2063	469*	33*	44.7	3.1	24.0	22.7	31.2	1.6	2.7
IT	57.25	6688	987	414	16.0	6.7	20.9	14.8	21.2	6.2	7.5
IRL	3.58	453	115	22	32.1	6.1	30.2	25.4	36.9	4.9	6.4
NL	15.60	1180	109	232	7.0	14.9	29.0	9.2	14.8	19.7	21.3
P	9.82	2730	624	75	63.5	7.6	25.6	22.9		2.8	
S	8.82	537	74	49	8.4	5.6	22.9	13.8	15.7	9.1	13.2
UK	58.28	3740	1039	208	17.8	3.6	33.3	27.8	32.6	5.6	5.1
All 14	372.2	43474	7048	2373	18.9	6.4	24.5	16.2	23.6	5.5	9.1

- Luxembourg is omitted because of its small number of deaths and consequent variability of the various ratios

* 1995 data

2.2 Major results from in-depth studies of crashes

The findings mentioned here indicate important characteristics of the crash-involvement of pedestrians and cyclists. Quantitative information is included for illustrative purposes only; results of particular studies may reflect national or regional conditions and should not be extrapolated to whole countries or across the EU.

Differences between age groups. There are various age-related differences in crash risk. The risk per head of dying as a pedestrian in a crash is four times higher for road users of 65 years and over than for all younger age groups. There is a similar but less pronounced difference for cyclists. About 30 per cent of children under 6 killed in road crashes are pedestrians. For cyclists, the death rate per head is high between the ages of 10 and 17.

Vehicles involved. Cars account for over 90 per cent of vehicles striking pedestrians and cyclists. However, large numbers of cyclist crashes not involving any other vehicle go unrecorded in the crash statistics; in a Dutch study that did include them, over 40 per cent of all cyclist crashes were falls (Schoon, 1996). Nearly 20 per cent of elderly cyclists involved in crashes are hit by another cycle or a moped, and these collisions often lead to serious injuries.

Crash circumstances – pedestrians. Only about 50 per cent of pedestrian deaths occur while crossing a road. About a quarter occur while boarding or alighting from a bus or getting into or out of a car. Others occur while walking along the road, playing, running, or working. Most fatal crashes involving pedestrians are not located at a marked crossing, the vast majority occurring more than 50m from such a crossing. Elderly people are most frequently hit by vehicles when halfway or further across the street, while children are mostly hit when starting to cross.

Crash circumstances – cyclists. Most fatal or serious cyclist crashes occur at junctions. Many are struck from the side while going straight ahead or turning across the path of oncoming traffic. There are indications that about 10 per cent of crashes involve loss of control of the cycle.

Intervisibility. Obstructed vision is a common factor for pedestrian crashes. In one study, almost a third of pedestrians said that something made it difficult for them to see the striking vehicle. Similarly, two-fifths of drivers said something made it difficult to see the pedestrian. A parked car was the most commonly cited source of obstruction. Only about one in ten drivers hitting a cyclist said they noticed them beforehand, whereas over two-thirds of cyclists said they had noticed the striking vehicle.

Familiarity with traffic situation. A high proportion of both pedestrians and drivers involved in collisions between them know the site and have travelled through it three to five times a week prior to the crash. Cyclists involved in crashes at junctions also tend to be familiar with the site. Of children aged under 7 injured in crashes, the majority are within 100m of home. In this age group, a larger proportion of crashes happen in lightly trafficked streets than is the case for older children and adult pedestrians.

Types of injuries. Head injuries are the major cause of death for three-quarters of cyclist fatalities. Head or brain injury account for about half of all younger hospitalised cycle crash victims. They are more often the result of crashes involving no other vehicle than of a collision with a motor vehicle. Therefore, serious head injuries experienced by cyclists could be effectively reduced by the general use of cycle helmets. Over a quarter of injured cyclists still experienced physical inconvenience two years after the collision (Larsen, 1994), and the proportion permanently disabled increases with age.

Alcohol and relative poverty Thirty-five per cent of adult pedestrians (over the age of 16) killed in a crash and tested for alcohol were found to have blood alcohol levels above the legal limit for driving. This rate was higher than that of drivers involved in fatal crashes (Fontaine et al., 1997). Injured adult pedestrians were found to be predominantly from low socio-economic groups (for example, 26 per cent of heads of household were unemployed).

2.3 General problems with sources of crash data

By far the most important information sources for quantitative statistical crash analyses are data collected by the police or similar agencies at national level. The

weaknesses of this source of information for pedestrian and cyclist casualties are well established:
Comprehensiveness and quality. The data are most often based on a limited number of variables describing crash characteristics, and they provide very little information on the injury consequences of crashes such as severity and types of injury, and resulting disabilities. The range of possible factors that can be detected and described on this basis is limited. Furthermore, the quality of statistical crash data in terms of completeness and accuracy is not always satisfactory.

Underreporting. Pedestrian and cyclist crashes are heavily and disproportionately underrepresented in the police crash statistics compared to what hospital records and other studies show (OECD, 1998). A particularly important problem is the substantial proportion of cyclist crashes that do not involve any other vehicle. Even in the case of the more severe injuries, the police very seldom record these crashes; they are therefore not adequately represented in the statistics.

Recognising these weaknesses, statistical analysis based on standard crash data needs to be complemented by approaches such as direct observation in traffic of events that are valid proxies for crashes (traffic conflict techniques); the observation of particular characteristics of traffic behaviour and analysis of their determinants; in-depth crash injury research; and collection of travel data about walking and cycling in urban areas, which barely exists in most EU countries. There is also a particular need for data about injuries in traffic to people with reduced mobility, in view of the growing concern to meet their requirements for mobility.

3 Key problems for pedestrians and cyclists in relation to the modern traffic system

The main problems for vulnerable road users are common to all EU Member States, although they may differ in extent. The key factor which underlies the complex mix of reasons for these problems is that the modern traffic system is designed largely from a car-user perspective resulting in a lack of coherent planning of route networks for pedestrians and cyclists.

Vulnerability
Even at relatively low impact speed, pedestrians and cyclists receive severe injuries, mainly because their only protection is their clothing. For cyclists a helmet provides useful protection against head injuries, but the use of helmets varies with age, gender and location.

Speed plays an important role in determining the severity of the outcome of collisions. If the collision speed exceeds 45 km / h, the likelihood for a pedestrian or cyclist to survive the crash is less than 50 per cent. If the collision speed is less than 30 km / h, more than 90 per cent of those struck survive (Carlsson, 1996).

Another aspect of vulnerability is that the weight and speed of pedestrians rarely pose any threat to other road users. Cyclists are sometimes a threat to pedestrians in this respect but of no threat to other road users. Since pedestrians and cyclists pose little threat to drivers, the drivers have less reason to be aware of them.

Flexibility
Pedestrians and cyclists are very flexible in their behaviour and flexibility is one of the main advantages of these modes. In relation to other road users, however, this presents a problem. A motor vehicle driver can never be sure when or where to expect a pedestrian or a cyclist. It is very difficult to influence cyclist behaviour by road markings or traffic signs. If a pedestrian or a cyclist gains significantly by walking across a lawn or cycling the wrong way along a one way road, then they do it. Pedestrians are even more flexible than cyclists: they can jump over fences and have hardly any stopping distance.

Instability
Pedestrians and especially cyclists may trip or fall in the traffic environment. A small mistake or a minor failure of the cycle may result in a severe outcome even though there are no other road users present. A pedestrian may stumble and receive serious injuries just because of an uneven surface. The instability of the pedestrians and cyclists is an even bigger problem when they are mixed with motor traffic.

Invisibility
Pedestrians and cyclists can be difficult to see. They are small compared to a car, and can be hidden by one. At night the problem is more severe. Pedestrians do not regularly carry lamps. Even after massive campaigns, pedestrians seldom wear luminous tags. Cycles are seldom equipped with proper lamps even though these are available. One reason is that cyclists do not perceive a benefit from the lamps because they are too weak to help in seeing the road surface.

Differing abilities
Pedestrians and to a large extent also cyclists are drawn from the entire range of the population. They include children with lack of experience, elderly people with reduced capacity and people with reduced mobility. No realistic licensing procedures could exclude them from the streets, even if it were conceivable to think of doing so in free societies.

Consciousness of effort
Making a detour in a motor vehicle may use extra fuel but for pedestrians and cyclists it means extra use of their muscles. They are therefore highly motivated to find and keep to the easiest routes, often the most direct ones. Studies have shown that pedestrians and cyclist have a higher value of time than drivers or those on board public transport vehicles.

Estrangement
Involvement in the traffic process varies from person to person and from situation to situation. When walking from one shop to the next, being a road user is not the primary task. Pedestrians are often primarily doing other things than travelling on foot. This, together with the fact that the modern traffic environment is designed largely for cars rather than for pedestrians and cyclists, creates a state of estrangement of pedestrians and cyclists. Cyclists more often make journeys, but even they are often treated as intruders in the traffic system rather than as an integral part of that system.

The key problems in combination

In real situations, difficulties for pedestrians and cyclists result from combinations of these key problems. A crash is seldom a result of one single problem. A pedestrian stumbling and becoming concussed on falling could stem from a combination of *vulnerability* – low speed is enough to cause concussion, *instability* – a slightly uneven footway resulted in the fall, *flexibility* – the pedestrian stepped sideways to avoid a puddle, *incapability* – the pedestrian was elderly and not agile, *consciousness of effort* – he tried to avoid a detour around the puddle, *estrangement* – he was primarily engaged in his shopping.

A cyclist colliding with a car could stem from *flexibility* – the cyclist was making an unorthodox turn, *instability* – even a slight contact with the car resulted in a fall, *invisibility* – the car driver saw the cycle too late, *estrangement* – the cyclist was just coming out of a park and was involved in an interesting conversation with a friend.

Insight into these key problems should be used to help in understanding the conditions under which traffic planning and management has to be carried out. Many of these problems are rather difficult to eliminate; good solutions are normally a result of countermeasures that address several of them together.

4 Managing exposure to risk

The safety of people walking or cycling in urban areas has to be considered in the context of policies for encouraging people to travel on foot, by cycle or by public transport rather than by car in order to reduce environmental damage, improve public health, and enhance the quality of life in towns and cities. These policies imply that attractive routes should be available for shorter journeys to be made wholly on foot or by cycle, and that it should be convenient to walk or cycle to and from public transport stops. Those who make part of their journey by car should also find it convenient to complete their journey on foot, by cycle or by public transport from an appropriate parking place. Account should also be taken of policies for improving access to all kinds of destinations for people with reduced mobility; these policies require, for example, that routes for movement on foot should be negotiable by wheelchair users and by the blind and partially sighted.

An important element in making walking and cycling attractive and convenient is that they should be safe: unless it is perceived to be safe enough to walk or cycle, people will not choose to do so, and even where risk is not perceived as a deterrent by the pedestrians and cyclists themselves, those responsible for transport policy should seek to reduce it as far as is reasonably practicable because of the social and economic costs of death and injury in crashes. There will sometimes be trade-offs between safety and other aspects of attractiveness and convenience.

4.1 Risks affecting walking and cycling

Safety of walking and cycling is jeopardised by three main kinds of risk: risk from traffic, risk of falling, and risk from crime. The last of these is more a social problem than a transport one, but transport policy can mitigate it by achieving routes for walking and cycling that are well-maintained, well-lit, well-used and overlooked, and provide their users with good visibility and intervisibility throughout their

journeys. Risk of theft of cycles can be reduced by providing secure or at least highly visible storage places for cycles at non-home destinations. Reducing the risk of falling is largely a matter of the detailed design and maintenance of the surfaces used by pedestrians and cyclists - not only on footways and cycle paths, but also on the carriageway, where the parts of the surface most used by crossing pedestrians or by cyclists should have the highest quality of surface and the highest priority for maintenance. Risk from traffic is essentially a matter of transport policy, including road safety policy (OECD, 1998).

4.2 Reducing risk from traffic

There are many ways in which transport policy in general and road safety policy in particular can contribute to reducing exposure to risk from traffic for those travelling on foot or by cycle. Risk from traffic consists mainly of risk from mechanised vehicles, but it also includes risk posed to pedestrians by cyclists and *vice versa*. It can be reduced by

- separating different kinds of road use to eliminate conflicts,
- creating more favourable conditions for integrating different kinds of road use through sharing of space, and
- mitigating the consequences of collisions where these nevertheless still occur.

Where separation can be achieved in ways which provide convenient and attractive routes for all road users, it very largely removes risk from traffic in the areas of separation - but this advantage may be offset by increased risk where road users re-enter shared space. Integration of different kinds of road use by sharing of space often has the advantages of requiring less adaptation of the roads and paths and enabling more direct routes to be provided. Taken together, these means of reducing risk require action in respect of location of destinations, layout of sites and buildings, design and maintenance of the road infrastructure, regulation of road use, design of the vehicles, and behaviour of the road users themselves.

In planning the evolution of land-use, priority can be given to locating the most likely destinations for walking and cycling - homes, schools, workplaces, shops, social and recreational facilities, and public transport stops - where they can be more readily served by safe, attractive and convenient routes for walking and cycling. As sites and buildings are adapted, redeveloped or developed for the first time, opportunities can be taken to achieve layouts which separate access by motor vehicles from that on foot or by cycle, and adapt the latter to the local network of pedestrian and cycle routes, including routes from public transport stops.

In the road infrastructure, priority can be given to identifying comprehensive networks of pedestrian and cycle routes and making these routes attractive and safe to use, having regard to and, if necessary, adapting the location of public transport stops. The networks as a whole should achieve a high degree of connectivity and individual routes within them should be direct and uninterrupted in respect of the journeys that people would like to make. Routes will typically consist of a mixture of sections of footpath or cycle path separate from any carriageway, wholly pedestrian areas with or without admission of cyclists, footways or cycle tracks alongside carriageways, and carriageways or other surfaces shared with motor vehicles. Where

routes cross appreciable flows of motor vehicles, careful attention will be given to the location and design of the crossing point. Where the routes are not separated from carriageways, and even more so where surfaces are shared with motor vehicles, the layout will be such that the speeds of the latter are moderated.

4.3 Urban safety management and sustainable safety

Density of development in urban areas offers the possibility, through land-use planning, for many of the purposes of day-to-day travel to be satisfied within distances short enough for walking and cycling if people choose to do so - though it cannot guarantee that they will so choose. It also makes viable relatively high levels of public transport services to provide for longer journeys, with associated demand for access on foot or cycle to public transport stops. At the same time, the density of road networks in urban areas offers great scope for providing safe, attractive and convenient routes for walking and cycling as part of the process of urban safety management (IHT, 1990) or the implementation of sustainable road safety (Dutch Ministry of Transport and Public Works, 1996). The key to this process is the availability of numerous alternative routes for most journeys through the network of roads, footpaths and cycle paths. Urban safety management and sustainable road safety adapt the layout of this whole network to provide a hierarchy of routes for pedestrians, routes for cyclists and roads with different mixtures of access and movement functions for use by motor vehicles. The motor traffic is managed so that it uses each road safely having regard to its functions, including any walking and cycling that takes place there. By its very nature, such comprehensive adaptation in the interests of safety will be the subject of safety impact assessment. The design and implementation of the resulting changes should also be the subject of safety audit (ETSC, 1997).

In the context of encouragement for walking and cycling, urban safety management should give high priority first to identifying the pattern of journeys that people would like to make on foot or cycle, and then to creating safe, attractive and connected routes for this pattern of journeys. These routes should be designated in conjunction with the functions of each road for all kinds of road user, and in particular so that motor traffic uses each road in ways that are consistent with the safety and convenience of pedestrians and cyclists. This should result in as much as is practicable of the motor traffic travelling on main roads where pedestrians and cyclists whose routes follow the main road can be separated from the motor traffic and those whose routes cross the main road can be provided with safe and convenient opportunities to do so, notwithstanding the possibly heavy flows of motor traffic. This may well present challenging problems of junction design. Routes for walking and cycling should follow more local roads or separate footpaths or cycle paths to the greatest extent that is consistent with the objective that these routes should be direct enough to be attractive to their intended users. Concentration of motor traffic onto main roads should enable the more local roads to be adapted to enable them to perform their functions in respect of motor vehicles consistently with their forming parts of safe and attractive routes for pedestrians and cyclists. The more these roads are used for walking and cycling, the more aware drivers will become of the likelihood of encountering pedestrians and cyclists, and thus the lower the risk that motor vehicles will pose to them. On public transport routes, whether bus or light rail routes on main or more local roads, or bus or rail services

on segregated tracks, the stopping places should be served by the network of routes for walking and cycling.

4.4 Motor vehicle design and road user behaviour for sustainable safety

Motor vehicles can be designed to be less injurious to pedestrians and cyclists who, despite all efforts to minimise the risk of this, are struck by them. Standards for pedestrian-friendly car fronts and for underrun guards on larger vehicles are important here. In due course, there is scope for in-vehicle telematic devices to limit the speeds of motor vehicles to the level appropriate to each length of road or area of shared surface, having regard to use by pedestrians and cyclists, and to further reduce the risk of collision. In the meantime, drivers need to be educated about the needs of pedestrians and cyclists and ways in which the road infrastructure is being modified to provide better for them, requiring in turn new patterns of driver behaviour, especially in respect of choice of route and choice of speed appropriate to each part of the chosen route.

Last but not least, and in the context of the provision being made for them and the changes in behaviour being required and asked of drivers, pedestrians and cyclists themselves need to be educated and encouraged to take steps that are open to them to reduce their own exposure to risk in the course of the increasing use they are being encouraged to make of walking and cycling as means of transport. They need to be fully consulted and informed about the routes being created or improved for them, and especially of any situations in which, for the sake of safety, any route is made somewhat less attractive or convenient in some other respect. Both pedestrians and cyclists also need to be encouraged to use clothing and devices that increase their conspicuity to drivers, and cyclists need to be encouraged to wear helmets.

In all these ways it should be possible to achieve considerable increases in the use of healthier and more environmentally friendly means of transport and still reduce the numbers of deaths and injuries among pedestrians and cyclists, and thus contribute to sustainable safety.

5 Casualty reduction

The process of adapting the layout and use of roads and paths in urban areas to manage the exposure of road users to risk will in many places be a lengthy one. At every stage in this process, the responsible authorities should be taking all practicable and affordable steps to reduce casualties in the prevailing circumstances and to contribute to their further reduction in the longer term. The measures available for this purpose are outlined in this section under the headings of road engineering, user protection and vehicle engineering, and educating, training and informing road users, including enforcing regulations.

5.1 Road engineering measures

Road conditions for pedestrians and cyclists can be made substantially safer to enable a higher level of walking and cycling while reducing casualties. Dedicated

facilities may be the solution in some instances, traffic restraint and speed reduction in others. A combination of measures should usually be applied and some potentially effective measures are discussed here.

The aim should be to minimise potential conflict between motor vehicles and vulnerable road users by engineering out potentially unsafe features on roads, including those relating to traffic management schemes and maintenance projects (Greibe, Nilsson and Andersen, 1998). Audits of existing infrastructure and planned construction, traffic management schemes and maintenance work are useful first steps.

5.1.1 Measures benefiting both pedestrians and cyclists

Effective measures will depend on the broader traffic, environmental, economic and planning objectives of the town or city. The success, or otherwise, of any measure will depend upon the social context, legal issues including traffic regulation, and public acceptability. The following hierarchy of measures should be considered before the design solution is chosen: traffic reduction; speed reduction; junction treatment; the redistribution of road space; and the provision of special facilities (IHT, 1996). These measures are not alternatives: implementing those higher up the hierarchy may make it easier to introduce successfully the lower level measures or may render them unnecessary. A high-quality infrastructure will incorporate many or all of them.

Traffic reduction Heavy traffic flows are a major deterrent to walking and cycling. Conflict between vulnerable road users and vehicles can be reduced by the introduction of car-free areas or pedestrian zones. Traffic and speeds may also be reduced by road closures. The closure of minor streets can offer lightly trafficked routes for cyclists and a safer pedestrian environment. An area-wide approach should be adopted to avoid displaced traffic leading to more crashes elsewhere. Even at low speeds, mixing with heavy traffic, especially lorries, is hazardous. The diversion of through and unnecessary traffic from some areas will reduce potential conflict but will require appropriate advance signing and, possibly, some road construction.

Speed reduction and traffic calming measures Speed of motor vehicles is critical to the safety of vulnerable road users. At low speeds drivers have more time to react to the unexpected and avoid collisions. At speeds of below 30 km/h pedestrians and cyclists can mix with motor vehicles in relative safety.

Traffic calming reduces the speed of motor vehicles by various physical modifications: vertical and horizontal deflections, changes in surface colour and texture, a reduction in overall carriageway area, and signs and other symbols to convey to drivers that they need to have greater awareness of vulnerable road users. Gateways may indicate entries into traffic calmed areas. Traffic calming measures, based upon various national guidelines, are now common throughout the EU. Such schemes should be introduced as part of area-wide urban safety management. In Denmark the EMIL project showed that traffic calming can lead to speed reductions of 5–40 per cent with an average reduction of 10 km/h (ETSC, 1995).

In shared-use areas rights of way may be altered so that pedestrians (and possibly cyclists) have priority over drivers (Greibe et al., 1998). Shared-use areas are usually supported by physical measures and lower speed limits.

Provision for on-street parking should form an integral part of traffic calming since parked vehicles can help reduce traffic speeds. Footway build-outs can define parking areas and improve visibility for pedestrians at crossing points. Planting schemes must not obscure pedestrians or cyclists.

Speed limits In urban areas, speed limits should reinforce an easily understood road hierarchy. They should be lowered when a consequent reduction in actual vehicle speeds can be expected and when the police can enforce the lower limit. Danish research has shown that a change in the general speed limit in urban areas from 60 km/h to 50 km/h resulted in a 6 per cent improvement in cyclists' safety (Jensen, 1998). Localised variations in speed limits are normally unnecessary where the character of the road limits the speed of most vehicles to a level appropriate to the conditions.

Speed limit zones of 30 km/h (20 miles/h in the UK/Ireland) are most appropriate where an urban safety management strategy has been adopted. Self-enforcing measures in the zones are usually necessary to reduce speeds. In the Netherlands 30 km/h zones generated a 22 per cent reduction in personal injury crashes (OECD, 1998).

Grade–separated crossings Pedestrians and cyclists are particularly at risk when crossing heavily trafficked roads and are generally safer when separated from traffic. To be successful, grade-separation, either by footbridges or subways, should be without steps or troublesome ramps and keep vulnerable road users on their natural desire-line whilst motor vehicles undergo the changes in grade and level. The main use is for crossing roads with speed limits of 60 km/h or higher or heavily trafficked roads. Subways should be brightly lit, regularly cleaned, have good through visibility and be consistently overlooked (IHT, 1997).

Signs, distinctive surfaces and road markings Consistent signing and distinctive surfaces help to advertise the presence of pedestrians and cyclists. Signing should indicate route continuity and pedestrian or cycle route priority. Advance warnings of pedestrians can help to slow traffic (Towliat, 1997). Road markings encourage driver discipline and warn of changes to the highway layout. They are self-explanatory and can reduce conflict, especially at intersections. Distinguishing cycle lanes by surface colour is useful. Coloured surfaces should be used consistently so that road users know what to expect. Raised rib road markings should not be used where cyclists are likely to cross them.

Maintenance A Swedish study (Oberg et al., 1996) found that 78 per cent of injured pedestrians and 42 per cent of injured cyclists in incidents not involving a motor vehicle considered that the condition of the road surface was of significance. Routes of importance to pedestrians and cyclists should therefore be identified for priority maintenance. Such routes require regular sweeping to remove debris and loose material as they are not routinely swept by motor vehicles.

Good winter maintenance is important also: for example, in Linkoping 70 per cent of pedestrian injuries occur in the winter (Oberg et al., 1996). Anti-skid surfaces reduce slipping dramatically: only 1 in 5 pedestrian injuries occur when surfaces are dry.

A good-quality riding surface is essential for the safety of cyclists (IHT, 1996). Relatively minor defects in pavement or track surfaces can be a real safety hazard for cyclists whereas for motorists they may be merely an inconvenience. As cyclists tend to use the edge of the carriageway, efficient drainage is important.
Provision should be made for pedestrians and cyclists at road works, with appropriate signing and routeing. Delays and detours for both groups should be minimised. Maintenance works should be undertaken with particular regard to people with reduced mobility. Reinstatement of the highway or footpath surface immediately after road works have taken place should be to the highest standards. Facilities such as tactile surfaces must be reinstated in full after street works have been undertaken.

5.1.2 Measures benefiting pedestrians

Everyone needs to walk – for work, shopping, education or leisure. Making the pedestrian environment safer will therefore be beneficial. In doing so it is essential to recognise the vulnerability of pedestrians and the special needs of the young, the elderly and those with reduced mobility.

The needs and behaviour of pedestrians while playing, meeting socially, or shopping are not the same as those related to reaching a destination. Increased protection is needed for the former since their attention may well not be on the traffic, and their movements may be erratic and thus unexpected by drivers (OECD, 1998).

Urban transport strategies should include the development and maintenance of a comprehensive, safe, well-signed and well-lit network of pedestrian routes, providing easy access to all major developments (see Section 4). Research in the UK indicated that 55 per cent of elderly pedestrians experience problems with cracked pavements; 40 per cent say that there is too much traffic; 31 per cent fear uncleared snow and wet leaves; 29 per cent have problems with pavement cycling; 27 per cent with vehicles parked on the pavement and 20 per cent because there is no pedestrian crossing; and 15 per cent want more time to cross the road (Pedestrians Association, 1995). Such issues should be addressed in maintenance programmes as well as the transport strategy.

Developing pedestrian networks Pedestrians aim to follow the shortest and most direct path to their destination and prefer to be able to see the way ahead. Footways and footpaths should be aligned accordingly. Feelings of personal security are enhanced where routes are used by substantial flows of people. Corners and angles of buildings or structures, where individuals might be hidden from one another, should be avoided. Safe play areas should be provided for children.

Adequate pavement width (usually 2.5 m) should be provided so that pedestrians need not walk on the carriageway (OECD, 1998) and the width is adequate for those using wheelchairs (IHT, 1991).

Pedestrian crossings Pedestrian crossings are perceived to be safe places to cross the road, although this is not necessarily the case (LRC, 1998). While crossings give some

protection to the young and elderly, many crashes occur in their vicinity: the 50m either side of a signalised crossing is particularly dangerous. Pedestrian casualties can be reduced by installing guardrails and some EU countries permit a stop line for vehicles a few metres before the crossing to reduce conflict (OECD, 1998).

Dropped kerbs at crossings assist those with physical impairments while tactile surfaces help those with visual impairments. Refuge islands (or a continuous central reservation) provide help in crossing. Zebra crossings are also often used because of their relatively low cost. Signal–controlled pedestrian crossings can improve safety especially on higher speed roads or those with high traffic levels (Jensen, 1998). School crossing patrols provide a managed means of safer crossing for children as a particularly vulnerable group. The choice of facility to provide will depend upon local circumstances.

Pedestrian priority areas Pedestrian areas may be designed as such or be conversions from streets used by vehicles, and their value in improving safety has been demonstrated widely, especially for shopping streets. Pedestrian areas may be exclusively for pedestrian use, for pedestrians and cyclists or for pedestrians and cyclists along with some permitted vehicles at certain times of the day. The facility for vehicles to use converted areas outside times of closure will often remain for reasons of access and servicing, but the surface and layout of the street can be designed for pedestrians, with a clear indication of the paths to be followed by vehicles when they have access.

Streets dominated by heavy flows of traffic tend to be threatening to pedestrians. On the other hand, traffic-free areas, such as shopping precincts, with too little activity, can also promote anxiety in pedestrians. Whilst the fear of personal crime may be out of proportion to its reality, the risks should always be considered in the layout and design of areas used by pedestrians.

Facilities for people with reduced mobility A significant proportion of people has some degree of reduced mobility and all of us are sometimes ill, impaired or encumbered. The resulting needs must be understood before facilities, especially pedestrian crossings, are designed or redesigned. Blind or partially-sighted people can usually follow kerblines or the facades of buildings, but they can have problems in finding their way in pedestrian areas (IHT, 1991). Different surface textures or directional guidance paving can help them. Street furniture can be a hazard and should not be placed on the natural routes taken by blind or partially-sighted people. Changes in level should avoid the exclusive use of steps. If steps are unavoidable, the top and bottom of flights of steps should have warning surfaces.

Guard rails A continuous safety fence on the edge of the footway can improve safety at conflict points but should be installed only where there are risks of crashes from pedestrians walking onto the road. Guardrails restrict people's freedom and are resented unless there is no practical alternative. Drivers must be able to see pedestrians waiting to cross at the end of a length of guardrail.

5.1.3 Measures benefiting cyclists

Cyclists can mix safely with traffic at speeds below 30 km/h. They can also mix safely with traffic at speeds between 30 km/h and 50 km/h unless there are significant numbers of lorries or child cyclists. Additional lane width is desirable

where traffic flows are heavy. Where traffic speeds are between 50 km/h and 65 km/h, segregation or additional lane width is necessary. Above 65 km/h, segregation is essential.

Link design Cyclists need space to cycle safely: they should not be expected to stay close to the nearside kerb at all times. Adequate width should be provided for overtaking other cyclists, to be passed safely by motor vehicles, and for cyclists to deviate around road defects, debris and other hazards. Danish studies show reductions of 35 per cent in cyclist casualties on links after the construction of tracks or lanes alongside urban roads (Herrstedt, 1997).

The appropriate link design will depend on the volume of cyclists, speed and volume of motor vehicles, the functions of the route and the physical opportunities present. It should also take account of the number of lorries, sight distances, on-street parking, the number and type of junctions and accesses to properties. The Dutch design manual provides guidance on when a cycle track, cycle lane or mixed use is appropriate (CROW, 1993).

Various approaches to on-carriageway provision can be adopted. Wider nearside lanes benefit cyclists' safety, particularly where there are significant numbers of lorries or buses, and several European authorities endorse their use. Bus and cycle lanes can also improve the safety of cyclists since they separate cyclists from general traffic (IHT, 1996). Bus lanes may be either with-flow or contra-flow. Cyclists should be allowed to use both. Particular care must be taken at bus stops to reduce cyclist/pedestrian conflict.

With-flow cycle lanes give cyclists a well-defined space and allow them to overtake safely. They can also contribute to traffic calming by visually narrowing the carriageway. However, cycle lanes require effective waiting and loading restrictions. Furthermore, there must be sufficient carriageway remaining for motor vehicles to pass each other safely. Where occasional encroachment by motor vehicles is essential, an advisory cycle lane may be useful.

Cycle lanes on links should be at least between 1.5m and 2m wide wherever possible: wider lanes allow safer overtaking but narrower lanes are permitted in some places. Widths of less than 1.5m give cyclists little room to manoeuvre around debris, potholes and drainage grates while a lane wider than 2m may be abused by motorists. If cycle flows are heavy (over 150 cyclists in the peak hour) 2.5m may be required or another arrangement may be necessary. There have been several studies of the safety of cycle lanes in relation to width and traffic levels (Angenendt, 1992 and Levelt, 1994). Cycle lanes should be located outside car parking or any bus bay, and not between car parking and the footway (Wilkinson, Clarke, Epperson and Knoblauch, 1994). Particular care must be taken when designing cycle lanes at junctions.

One-way streets can endanger cyclists since they introduce additional hazards at junctions where unusual road positioning is required. Contra-flow cycle lanes can be relatively safe for cyclists as there is good intervisibility between them and oncoming vehicles (Werele, 1992).

Cycle tracks or paths can provide safe off-carriageway provision within the highway. Cycle tracks remove cyclists from hostile traffic conditions and provide a higher degree of a safety than cycle lanes. Nevertheless over half of cyclist casualties in Sweden are injured on cycle tracks and paths (Oberg et al., 1996). Cycle tracks are most useful on roads with few junctions where traffic volumes or speeds are high, and on routes used by lorries. Tracks should be at least 2m wide but 2.2m is recommended, and they should be provided on both sides of the road to minimise the need for crossing.
Route continuity is crucial and cycle tracks should not be discontinued at side roads and junctions. A through cycle track should have priority over minor side roads and accesses made clear by continuity of surface colour and markings. The track can be continued across a minor road at footway height, creating a humped crossing.

Junctions A cycle network is only as good as its weakest features and these are often the junctions. In Denmark over 60 per cent of crashes involving cyclists occur at junctions (DRD, 1997). Junction designs that are cycle-friendly are also likely to be pedestrian-friendly.

Drivers should know where to expect to find cyclists at junctions. Layouts that place cyclists outside the driver's normal field of view are likely to be hazardous; those that place the cyclists in front of and reasonably close to the driver tend to be safer (Herrstedt et al., 1994). Free-flowing arrangements, particularly near-side turning and merge lanes for vehicles, are particularly hazardous for cyclists. At some junctions vehicles are prohibited from making certain turns but there is often no reason to include cyclists in the prohibition.

Cyclists may find it difficult to make opposed turns at traffic signals. Some may position themselves at the front of the traffic but this usually involves crossing the stop line and may also make it difficult to see the signals. Advanced Stop Lines (ASLs) provide a waiting area for cyclists between two stop lines - one for drivers and an ASL for cyclists, so that waiting cyclists are ahead of motor vehicles and can be seen easily. Danish research shows that crashes caused by turning vehicles crossing the line of cyclists going straight ahead are reduced by 35 per cent by ASLs (Herrstedt, 1997). Separate cyclist signals that give them a leading light may also reduce crashes involving vehicles turning across their line of movement (Greibe et al., 1998). They can also reduce the crash risk to children by up to 90 per cent (Leden, 1988).

Crossings Unsignalled crossings will normally be satisfactory on minor roads where two-way traffic flows are less than 400 vehicles/h. If possible, priority should be given to a primary cycle route over a minor road. Unsignalled crossings can also be used on dual carriageways with flows of up to 1500 vehicles/h. Single carriageway roads with higher traffic flows that can be divided by a central island may also be suitable for unsignalled crossings. Single carriageway roads with two-way peak flows of more than 1000 vehicles/h require signal-controlled crossings. These are also likely to be required where speed limits are 60 km/h or above, or where a high proportion of cyclists are children.

Where both cyclist and pedestrian flows are high and the predominant cyclist movement is straight across the road, a parallel cycle/pedestrian crossing should be

provided. In the UK Toucan crossings provide a controlled combined crossing for both cyclists and pedestrians and can be incorporated within signalised junctions.

Roundabouts Experience of roundabouts varies. Although smaller roundabouts can reduce traffic speeds, large roundabouts and gyratories are the feature of the road network most feared by cyclists: in the UK cyclists are some 15 times more likely than car users to suffer a crash at a roundabout. Over half of these crashes are due to motorists entering the roundabout and hitting cyclists (Layfield and Maycock, 1986). There are many ways to make roundabouts safer for cyclists (Allott and Lomax, 1993). These include reducing the width of the circulatory carriageway, increasing deflection on entry and improving signing, road markings and conspicuity. Reducing the number of lanes entering and leaving the roundabout has reduced crashes by 80 per cent at sites in the Netherlands (Dykstra, 1998). Annular cycle lanes may be provided around the outside of larger roundabouts. Signal-control, particularly with ASLs, can make large roundabouts safer for cyclists. Research indicates that crashes involving cyclists can be reduced by 66 per cent on roundabouts with full-time signals on all or some arms (Lines, 1995). However, large gyratories are still likely to be intimidating if traffic speeds are over 50 km / h.

Research suggests that some roundabouts are working well for cyclists (Balsiger, 1992). Elvik's (1995) studies in Norway concluded that roundabouts reduced personal injury crashes by 30 – 40 per cent, usually on roads with relatively low vehicle flows and speeds but high flows of cyclists. Mini-roundabouts can form useful features in traffic calming schemes.

5.1.4 Potential conflicts between pedestrians and cyclists

Pedestrian areas By physically restricting access for vehicles, pedestrian zones create an environment where travel on foot and by cycle is safer. Opinion on admission of cyclists to these areas may be divided, but there is a need to avoid pedestrian areas resulting in unsafe or inconvenient conditions for cyclists, for example by forcing them to use busy distributor roads. In Mechelin, cycling is permitted in pedestrian streets in order to avoid detours for cyclists and this has so far proved to be safe (Dykstra et al, 1998).

Segregating cyclists and pedestrians in pedestrian areas will not always be possible. Where it is desirable, cycle movements can be combined with those of selected vehicles, such as buses and service vehicles, permitted at particular times of day or channelled by defined paths. In Bremen motor vehicles are prohibited from the large central square and many neighbouring streets, permitting free and comparatively easy access for pedestrians and cyclists. Cyclists and pedestrians can move freely, while trams and buses - with their set movements - are easy to anticipate.

Research in the UK indicated that conflicts between cyclists and pedestrians in pedestrian areas were less of a problem than appeared (Trevelyan and Morgan, 1993). Crashes in pedestrian areas between pedestrians and cyclists occur very rarely while cyclists tend to respond to pedestrian density, modifying their speed, dismounting and taking avoiding action where necessary.

Conversion of footways Cycling on the footway is common. Indeed in some countries, such as Belgium and the Netherlands, small children are allowed to cycle there. However it is of much concern to many pedestrians, particularly the elderly

and people who are visually impaired. In specific instances where no on-carriageway solution can be found, and where visibility is good, it may be appropriate to convert the footway to shared use. Widening of the footway clear signs and markings will help to make shared use more acceptable. Segregation by white line only may be expedient but segregation by kerb or level is preferred by the visually handicapped.

Bus stops A number of crashes between cyclists and pedestrians occur at bus stops. Ways of overcoming this problem include using a different colour for the cycle lane at the stop or rumble strips to guide cyclists away from potential conflict. However, bus stops on refuges in the middle of streets can be particularly hazardous for pedestrians (OECD, 1998).

5.2 User protection and vehicle engineering measures

Cyclists can be protected by various measures, some of them applied or directed to the other object or vehicle involved in the collision. Those applied to motor vehicle measures will also contribute to casualty reduction amongst pedestrians, most of whom are struck by passenger cars. The main measure that pedestrians can take for their own protection is to wear clothing that increases their conspicuity, especially in poor daylight and in darkness.

5.2.1 User protection

The cycle and its equipment The visibility of the cycle and its user is an important factor in preventing crashes. More than 30 per cent of the Dutch cycle crashes occurring at night or in twilight could have been avoided if cycle lighting had been working (Schoon, 1996). In Denmark, legislation in 1998 providing for safety equipment for cycles requires lamps to be visible at a distance of 300 m and the fitting of front, rear and wheel reflectors. The quality and use of lights can be improved by enabling the storage of separate light systems or by designing the lighting into the cycle frame. The use of rear view mirrors can be important, especially for elderly road users, to improve the cyclist's vision.

Failures of cycle components, like a sudden crack or a brake failure, can cause serious crashes - 10 per cent of the cycle collisions in The Netherlands for example. In 50 per cent of cycle collisions caused by such failures, someone was injured, and one third of these needed medical treatment (Schoon, 1994).

Cycles show large differences in component strength and the reliability of brakes and lighting. Cycles are often seen as consumer goods rather than road vehicles, resulting in too little maintenance. In some countries, safety checks or training programmes at schools are carried out by the police. A checklist for 'safety cycles' exists in Germany. EU-wide protection for cycle users would be offered by an EU whole vehicle type approval sceme for cycles.

About three-quarters of crashes involving cycle passengers in The Netherlands involve feet being trapped in the wheel spokes and 60 per cent of cycles have no protection system to prevent this (Schoon, 1996).

A European standard is needed also for cycle child seats: a Dutch study showed that at least 45 per cent of cycle passengers aged under 12 used such a seat, but 22 per cent of these seats were considered to be poor (Schoon, 1996). The anchorage of luggage could also be improved. Trailers designed for luggage and passengers are being used increasingly.

Cycle helmets Head and brain injuries sustained by cyclists result more often from crashes involving no other vehicle than from a collision with a motor vehicle. Serious head injuries could be reduced effectively by bringing cycle helmets into general use. Several studies indicate that cycle helmets reduce fatal and serious injury by between 45 and 80 per cent, and a European standard (EN 1708) exists for them.

In countries which do not require the use of helmets by law, the wearing rate is normally less than 10 per cent (Weiss, 1994), but mandatory use is not recommended for the time being, because studies in Sweden, Finland and Australia indicate that people cycle less if helmet wearing is required. Instead the use of cycle helmets should be strongly encouraged, partly by making their design more attractive and providing for convenient and secure helmet storage on the cycle.

5.2.2 Motor vehicle measures

Injury to pedestrians and cyclists can be reduced by applying new technologies in motor vehicles in two forms:

- active safety measures aimed at crash avoidance; and
- passive safety measures aimed at reducing injury in crashes that nevertheless happen.

Crash avoidance With respect to lighting two aspects can be distinguished:

- visibility of the vehicle itself to other road users; and
- vision enhancement for the driver of the vehicle.

About 30 per cent of struck pedestrians did not see the car before the collision. Location of parking to give pedestrians a better view and use of daytime running lights are needed to improve the visibility of oncoming vehicles.

Telematics could contribute to reducing crashes including collisions with pedestrians and cyclists through speed limiters to enforce the posted speed limit, collision avoidance systems and autonomous intelligent cruise control to maintain safe headways (ETSC, 1999b). Vision enhancement systems including the use of radar, infrared cameras, image recognition technologies and head-up displays could support the driver, especially at night and in bad weather. Micro-cameras are being used to avoid the blind spot to the rear, which is especially important for heavy good vehicles to help prevent their running over vulnerable road users when turning. However, some of these devices may lead drivers to adapt their behaviour, for example by driving faster when vehicle stability and driver vision are improved (OECD, 1990, ETSC 1999b) This needs to be studied carefully before measures are introduced on a large scale.

Passive safety In most of their collisions with motor vehicles, pedestrians and cyclists are hit by the front of a passenger car. By 1994 the European Experimental Vehicles Committee (EEVC) had developed a complete series of tests to assess the

injuriousness of the fronts of passenger cars (EEVC, 1994). Crash dummy parts used in these tests represent an adult leg, upper leg and head, and a child head. These are used to evaluate respectively the bumper, the bonnet leading edge and the bonnet top of the passenger car in respect of the level of injury reduction achieved by their design. The EEVC test methods were further improved in 1998.

If all cars on the road today were designed to pass the EEVC tests, up to 2100 fatal and 19,000 serious pedestrian and cyclist casualties could be prevented annually (ETSC, 1999). Requiring new cars to pass EEVC tests is one of the most important actions that EU could take to improve road safety.

Since the end of 1996, the EEVC tests have been used in the European New Car Assessment Programme (EuroNCAP), which provides consumer information ratings on the crash test performance of new cars. The results show that current car designs do not fulfil EEVC pedestrian protection requirements. However, the EuroNCAP programme is influencing the design and safety aspects of cars and further EU financial support is needed so that a full range of models can be tested.

The EEVC has also shown that so-called *bull-bars* made of steel tubes can be very pedestrian and cyclist unfriendly (EEVC, 1996) and the EEVC tests mentioned previously would prevent any harmful designs.

When heavy good vehicles and vulnerable road users are side by side and the vehicle turns in their direction, the pedestrian or cyclist is at risk of being run over by the vehicle. More than 30 vulnerable road users were killed and more than 80 seriously injured in this way in The Netherlands in 1995 (Schoon, 1996). Side protection which closes off the open space between the wheels of the heavy good vehicle is already quite common, and is preferable to the open frame permitted by current legislation. Closed structures also reduce fuel consumption by 5 per cent, making it advantageous to fleet owners themselves to adopt them (Schoon, 1996). The EU should require the fitment of appropriate side guards to all new heavy goods vehicles.

5.3 Road user measures

5.3.1. Information, education and training for all ages and user groups

Road engineering, user protection and vehicle engineering measures for casualty reduction are directed at specific high risk behaviour or traffic situations and consequently have clear crash and injury-reducing potential.

Information, education and practical training, on the other hand, are essential to acquiring the attitudes, skills and knowledge needed for safe road use, as a pedestrian or cyclist from childhood through to old age, but it is difficult to quantify their casualty reduction potential. They have an important role to play in achieving:

- Increased awareness about crash risks
- Increased understanding and acceptance of the need for road safety measures
- Transference of safety skills.

Training and education are not only for the young: they also have a role to play for experienced road users, for example for those who have committed particular traffic offences or whose changing capabilities require new skills and strategies to cope with daily traffic.

Users of the roads today are having to cope with increasingly complex demands of the system and there are limits as to what road safety benefits should be expected from education and training without appropriate urban safety planning and management. These must take greater account of the capabilities of road users, particularly those who are most vulnerable: children and the elderly.

Not only have pedestrians and cyclists to be educated, but also car drivers, parents and teachers as groups that are able to influence strongly the behaviour and learning of children as pedestrians or cyclists, and those responsible for the formulation of traffic rules, for driver instruction and for planning and building the traffic environment to be used by pedestrians and cyclists (Wittink, 1998).

Education and training measures for children Children typically begin to use the roads as pedestrians at the kindergarten age; the same is true for the use of cycles (mostly for play, but also near the roads). The age distributions of pedestrians and cyclists involved in crashes show the relative importance of these types of risks for children (as pedestrians greatest at age 6 to 8 and as cyclists at age 11 to 14).

In general, the goals of traffic safety education for the younger age groups are twofold:

- to inculcate risk awareness and positive attitudes to road safety which may be carried throughout life.
- to encourage awareness of the environmental and health benefits of walking and cycling.

For pre-school children

The roles of parents and other carers are to:

- decide where children can play safely without continuous supervision by adults;
- ensure use of passive safety devices during travel by car; and
- try continually to improve the basic abilities of children as pedestrians including the understanding of social interactions in traffic.

The roles of kindergartens or nurseries are to:

- develop in the children a broad range of basic skills;
- improve understanding of day to day traffic situations, especially through outings; and
- encourage parents and other carers in safety education in the home and to integrate their efforts with those of the kindergarten or nursery.

In several EU countries these activities are supported by non-governmental traffic safety organisations or special branches of the police. Generally, however, too little is known about the road safety work of kindergartens and nurseries.

For school-age children and young people

Best practice in road safety education in school for ages up to 10 or 12 involves explicit time tabled curricula for each grade. It should impart both knowledge and age-related practical training in road use as a pedestrian or a cyclist in active co-operation with children's families. Particularly important are:

- walking to and from school (safer routes, dangerous crossing situations, safe play);
- using school or public transport (behaviour and risks at stops and during travel);
- programmes for cyclist training.

Well established programmes for cyclist training are offered in different countries, with target ages ranging from 8 to 12 years, in some cases influenced by national rules about on-road cycling. Best practice training schemes comprise:

- combinations of theoretical and practical training concluding with a cycling test of theory and practice, with a clear understanding that attendance at the training and success in the test do not in themselves make children competent to cycle on the roads; and
- learning environments including for practical training traffic gardens and later on real traffic situations.

In many countries, cyclist training is realised by school teachers in co-operation with the local police. The latter can be necessary for training in real traffic situations. Some countries have specific curricula and timetables for traffic safety education in at least the first few years at school. Even for these countries, doubts often are expressed about the quality and quantity of this teaching. A major weakness is that traffic safety education is very often not a part of vocational training for teachers and kindergarten staff. Guidelines on best practice in standards for traffic education and initial and in-service training for professionals would be helpful at EU-level.

Driver education and training In addition to the knowledge and skills required for safe driving in general, with the safety of pedestrians and cyclists in mind learner drivers should be trained specifically to recognise situations in which vulnerable road users may be encountered and placed at risk, and how to respond to these situations in ways that minimise that risk, having particular regard to the limited capabilities of children, elderly people and people with reduced mobility. The initial training given by professional driving instructors should cover this aspect specifically and the instructors should be trained in doing so.

Subsequent information to drivers about changes in the traffic environment should give particular emphasis to changes that impinge on the safety of pedestrians and cyclists.

Older road users A fundamental problem in informing and training elderly people as pedestrians and cyclists is their low receptiveness. This makes it all the more important to develop suitable programmes for this target group as their numbers rise over the coming decades and the value of continued physical activity to their health is increasingly recognised.

Getting the most out of training Direct safety benefits from education, training and information activities cannot usually be proved by empirical studies and negative effects have even been found (OECD, 1998). Insufficient consideration of safety-reducing side-effects is probably one of the most critical failings of measures intended to improve traffic safety by education and training. One of the most important principles is the recognition and reduction of false expectations of the trainees. Ways of achieving this objective have to be derived by systematic empirical studies.

5.3.2. Encouraging user compliance with road safety rules

In order to have an impact on safety, legislation should address well established safety problems and take account of the latest research and experience internationally. When enforced, many safety rules continue to play a major role in casualty reduction – alcohol limits, speed limits, seat belt and helmet use, some of which have been harmonised at EU level.

ETSC reviews (1997,1999c) have highlighted the importance of encouraging compliance with such requirements, the varying levels of compliance in different Member States and successful international best practice in increasing compliance. Whereas the enforcement of legislation is a matter for Member States, the EU can play a key role in encouraging information exchange on successful best practice amongst policymakers and safety professionals.

User and safety organisations can be further encouraged and supported in assisting with the dissemination of knowledge about traffic rules and regulations. Pedestrians (especially children and elderly people) and cyclists who have not taken a driving test may not be aware of important traffic rules, and all road users encounter unfamiliar rules when they travel to different Member States. The idea of a devising and widely disseminating a European Highway Code containing the most important traffic rules from each Member State has much merit. It would provide an opportunity to emphasise to drivers throughout Europe that most national highway codes in Europe urge or require them to behave with consideration towards vulnerable road users, especially children, the elderly persons and those with reduced mobility.

5.4 Training of professionals and information exchange on provision for pedestrians and cyclists

5.4.1 Training of professionals

School teachers According to the results of two questionnaires (ERSF, 1996(a),(b)) answered by 14 EU Member States,

at the pre-school level, traffic education is part of the initial training for kindergarten or pre-school teachers in only 3 countries, and in these and 4 other countries some supplementary training or in-service courses are given by traffic organisations;

at the primary school level, teachers in only 6 countries have traffic education included in their initial training, with in-service training offered in 13 countries, but varying greatly in extent and frequency; and

at the secondary school level, for the age group 10-14 teachers in 6 countries receive traffic education included in their initial training, and for the age group 14-18 this is the case in only 3 countries, with in-service training offered in 6 countries for the age group 10-14, and in 4 countries for the age group 14-18, mainly by road safety organisations.

These results show clearly the lack and insufficiency of preparation of teachers for the very demanding task of traffic safety education including behaviour as pedestrians and cyclists. This should be rectified by the responsible authorities.

Driving instructors According to the results of a European study (CEC, 1995), a would-be driving instructor must possess a secondary school certificate, have reached a certain age, in most countries have held a driving licence for from 2-6 years, and undertake training leading to a written or oral and practical examination. The duration of the training varies from 2.5 months to 3 years. The degree to which understanding of the safety of pedestrians and cyclists is covered by these requirements is unclear.

Providers of facilities for pedestrians and cyclists
Targeting senior local authority management to ascertain how they assess cycling and walking in their own organisation is necessary, as many seem to attach a low priority to these issues. Two key requirements must be acknowledged: the need for greater awareness of the importance of designing for pedestrians and cyclists; and the need for better practical skills for practitioners. Professional training should aim to ensure that walking and cycling issues are not divorced from other aspects of traffic engineering, traffic management or urban design. Indeed they should be fully integrated into formal training. It is essential that these matters are covered as part of an inter-disciplinary approach given the wide range of professionals responsible.

There is still much emphasis on providing pedestrian and cycling facilities as an afterthought to other schemes rather than considering it as an integral part in the planning and design of transport facilities. If senior traffic engineers are not made fully conversant with the needs of pedestrians and cyclists there may be a tendency to leave everything to a relatively junior officer. This means that the provision of facilities could take place outside of the context of overall transport planning or traffic engineering, whereas it should be an integral element. Currently within local authorities few senior officers have expertise on these issues. A senior person should be explicitly responsible for including provision for pedestrians and cyclists in the design process.

Perhaps the single most important issue is the need for training of existing qualified professionals in the planning, design and construction of pedestrian and cycling facilities. This is required for town planners, urban designers, architects, and housing and education professionals as well as those working in transport.

5.4.2 Interdisciplinary training and dissemination of knowledge
In order to provide safer conditions for pedestrians and cyclists holistically, an interdisciplinary approach is required. Professional training and information exchange is therefore required in and between various areas such as: traffic psychology, law-making and enforcement, traffic management, highway and traffic

engineering, transport planning, town planning, architecture, urban design, public relations and research.

The authors have found no training concept to fulfil this need in the EU countries. There are some courses offered by universities and colleges to give students a holistic approach to transport without focusing upon developing individual specialities, but these can give only limited coverage to the safety of pedestrians and cyclists.

Additional training is given by professional institutions, and conferences, workshops and seminars enhance the understanding of a range of transport topics including walking and cycling. The programmes suggest that there is only limited interdisciplinary information exchange and still a great deal of specialisation individual disciplines.

There is no comprehensive database on what is being offered by universities, colleges and professional and private institutions in the field of interdisciplinary traffic safety work generally, let alone specifically concerning safety of walking and cycling in the EU. The EU should investigate existing levels of training and qualifications and their shortcomings.

A wealth of knowledge on improving safety of pedestrians and cyclists is already readily available via publications produced by governments and other bodies. The problem would appear to be one of national and local authorities not being able or willing to allocate sufficient resources to training or to drawing systematically upon information currently available. It is important to make sure that current information is widely disseminated. The EU can play a key role in helping to disseminate technical guidance and by synthesising best practice principles in EU guidelines.

6 The need for further research

Enough is already known to enable work to be started without delay in providing for safer walking and cycling in the EU without risk of misdirecting resources in the early stages. But there are three important areas in which greater knowledge and understanding will be needed in order to maintain progress cost-effectively over the decade or more that will be needed to achieve the transformation of conditions for pedestrians and cyclists that is implied by the approach advocated in this review. The three areas are:

- deeper understanding of the change that is needed and its implications;
- fuller quantification of the problem and of progress made in addressing it; and
- safer cycles and further techniques of crash protection for pedestrians and cyclists.

6.1 Deeper understanding of the necessary change

Investigation is needed into

- how walking and cycling can form an integral and attractive part of daily travel;

- preconditions for and safety implications of large increases in walking and cycling;
- what makes a route attractive or unattractive for pedestrians or cyclists, including subjective and objective risk;
- implications for pedestrians and cyclists of implementation of the intelligent transport system (ITS);
- health effects and risks of walking and cycling by the elderly;
- the mechanisms whereby walking and cycling are safer where there are more pedestrians and cyclists about, and
- the incidence of injury as road users to people with reduced mobility.

6.2 Fuller quantification of the problem and of progress made

Economical but statistically sound techniques of survey and analysis need to be developed and tested for

- comparing the risks of travel on foot or by cycle with those of realistic travel alternatives in a range of specific situations;
- quantifying death, injury and other harm arising from walking and cycling without the involvement of a motor vehicle or in unreported collisions with motor vehicles, and categorising the ways and circumstances in which they arise;
- monitoring the amounts of walking and cycling locally in urban areas;
- assessing patterns of potential movement on foot or bicycle in each part of an urban area; and
- monitoring the effectiveness of education, information, publicity, road user training and training of professionals relevant to the safety of walking and cycling.

6.3 Safer cycles and further crash protection

Mechanical engineering and biomechanics research is needed into

- development of European standards for safe cycles;
- development of cycle lamps that are cheap, reliable and convenient to use in real cycling conditions;
- development of a parents' cycle for carriage of young children and cycle passengers;
- improvement of cycle helmets to protect the face, to fit better, and to be more attractive to users;
- the possibility of child seats for use interchangeably between cars and cycles; and
- reduction of head injuries to pedestrians and cyclists from striking the windscreens and A-pillars of cars.

Much of the research required in the three foregoing areas is appropriate for EU funding.

7 Conclusions and recommendations

In 1996 more than 9,400 pedestrians and cyclists died in EU countries contributing around 25 per cent of all road deaths. The small proportion of pedestrian and cyclist casualties that occur in rural areas are relatively severe and should not be forgotten, but this review is concerned with the great majority that occur in urban areas.

The overall long term trend in deaths has been downward for both pedestrians and cyclists, but this may be due in some instances to a decline in walking and cycling as more people take to their cars for local journeys. However, this trend may be influenced in future by the encouragement now being given in several Member States to travel by foot, bicycle or public transport. As travel by public transport is also encouraged, increasing account needs to be taken of the safety of walking or cycling to catch the bus, tram or train. Walking and cycling have much greater risk levels per hour than travel in public transport vehicles.

It should be a high priority for those responsible for traffic systems in our urban areas to cater much better for the needs and physical vulnerabilities of pedestrians and cyclists, including people with reduced mobility. The key strategies for achieving a safe traffic system for pedestrians and cyclists are:

- Managing the traffic mix, by separating different kinds of road use to eliminate conflicts where conditions are favourable to separation;
- Creating safer conditions elsewhere for integrated use of road space, for example through speed and traffic management, increased user and vehicle conspicuity, and vehicle engineering and technology;
- Modifying the attitudes and behaviour of drivers of motor vehicles through information, training and the enforcement of traffic law;
- Consulting and informing pedestrians and cyclists about changes being made for their benefit, and encouraging them in steps that they can take to reduce their risk;
- Mitigating the consequences of crashes through crash protective design and encouraging the use of protective equipment.

And, to these ends

- Changing priorities in the minds of professionals and policymakers responsible for the traffic system through sharing of experience and promotion of research findings, and encouraging them to convince the public of the need for change.

By implementing known countermeasures it should be possible to achieve considerable increases in the use of healthier and more environmentally friendly means of transport and still reduce the numbers of deaths and injuries among pedestrians and cyclists. Deep commitment is needed from policymakers at local, national and EU levels to bring about this positive scenario. The following actions are recommended at these three levels.

Recommendations

For action by Member States and Local Authorities

- Give priority to the safety and convenience of walking and cycling in policymaking for planning, development and transport in urban areas, and in the implementation of development plans and the maintenance and enhancement of the transport and traffic systems of towns and cities.

For action by the EU

- Give priority to the safety and convenience of walking and cycling in all aspects of policy-making relevant to planning, development and transport in urban areas and encourage Member States and Local Authorities to do likewise.

- Encourage Member States to collect exposure data on pedestrian and cyclist travel and include it in the CARE database.

- Regularly ascertain level of under-reporting and extend the European EHLAS database to include road accident reporting.

- Encourage information exchange to promote better conditions for walking and cycling through development of EU technical guidelines for professionals particularly on:

  - Ways of providing for walking and cycling
  - Safety audit and safety impact assessment
  - Urban safety management
  - Speed management
  - Low cost / high return road safety engineering measures
  - Training and encouragement for drivers in helping the integration of pedestrians and cyclists into the traffic system
  - Initial and in-service training in the integration of pedestrians and cyclists for those involved in road safety education and training, driver training and the enforcement of traffic law
  - Road safety education and training at pre-school, primary, secondary and tertiary levels, emphasising activity as pedestrians and cyclists
  - Education and training of elderly road users
  - In-service training for professionals in providing facilities for walking and cycling.

all in the context of the interdisciplinary approach that the task requires.

- Bring forward mandatory EU fitment requirements for:

  - Safer car fronts for pedestrians and cyclists incorporating EEVC test procedures
  - Closed sideguards on all new heavy goods vehicles
  - Daytime running lights for motor vehicles

- Give more financial support to Euro NCAP
- Introduce EU Whole Vehicle Type Approval for cycles incorporating a range of technical safety criteria
- Develop a European standard for cycle child seats and promote the use of cycle helmets for which a European standard (EN 1708) already exists
- Develop and disseminate advice on sensible road use via a European Highway Code.

References

ALLOTT and LOMAX CONSULTING ENGINEERS (1993) *Cyclists and Roundabouts - Update Report.* Cyclists' Touring Club.

ANGENENDT, W. (1992) *Influence of the Installation and Design of Cycle Paths on Road Safety*. BSV.

BALSIGER, O. (1992) *To plan for cycling is to encourage it*. The Cycle: Global Perspectives Velo Mondiale Conference papers, September, Quebec.

BAMBERG, R., ZELLMER, H. (1994) *Nutzen durch fahrzeugseitigen Fußgängerschutz (Benefits from Vehicle-Pedestrian Protection Measures).* Berichte der BASt, Fahrzeugtechnik Heft F5, Bergisch Gladbach, Germany.

CARLSSON G.(1996) Working material based on data from Switzerland, Germany and Austria, NTF, Sweden.

CEC (1995) *Traffic education and training of young drivers*. Final Report of WP2, Directorate General of Transport, Commission of the European Communities VII / 151 / 1995, Brussels.

COATES, N. (1993) *The safety benefits of cycle lanes*. Unpublished paper prepared for Velo-City '93 Conference.

CROW (Centre for Research and Contact Standardisation in Civil Engineering) (1993) *Sign up for the bike. Design manual for a cycle-friendly infrastructure*. The Netherlands.

DRD (1997) *Handbog I Trafihskkerhedsrevision.* Vejdirektoratet Report, Danish Roads Directorate.

DYKSTRA, H., LEVELT, P., THOMSEN J., THORSON O., VAN SEVEREN J., VANSEVENANT P., NILSSON P., JORGENSEN E., LUND B. & LAURSEN J. (1998) *Best Practice to Promote Cycling and Walking.* DRD.

EEVC (1996) *EEVC test methods to evaluate pedestrian protection afforded by passenger cars.*
Presented to the 15th ESV Conference, Melbourne, Australia.

EEVC (1994) *Proposals for methods to evaluate pedestrian protection for passenger cars.*
Final EEVC WG10 report.

EKMAN, L. (1996) *On the Treatment of Flow in Traffic Safety Analysis.* Lund Institute of Technology.

EKMAN, L. AND KRONBORG, P. (1995) *Traffic Safety for Pedestrians & Cyclists at Signal Controlled Intersections.* TFK.

EKMAN, L. AND DRASKOZY M. (1992) *Trials with Microwave Detection of VRU & Preliminary Empirical Model Test*. Institute of Transport Studies Leeds WP336.
ELVIK, R. (1995) *Working Document for the Traffic safety manual*. TOI.

ERSF (1996a) *Traffic education at the pre and primary school level in EU countries*, European Road Safety Federation, Brussels.

ERSF (1996b) *Traffic education at the secondary school level in EU countries*, European Road Safety Federation, Brussels.

ETSC (1995) *Reducing traffic injuries resulting from excess and inappropriate speed.* European Transport Safety Council, Brussels.

ETSC (1997) *Road safety audit and safety impact assessment*. European Transport Safety Council, Brussels.

ETSC (1999) *Safer car fronts for pedestrian and pedal cyclist protection*. European Transport Safety Council, Brussels.

ETSC (1999a) *Exposure data for travel risk assessment: Current practice and future needs*, Brussels

ETSC (1999b) *Intelligent transport applications and road safety*. European Transport Safety Council, Brussels.

ETSC (1999c) *Police enforcement strategies to reduce traffic casualties in Europe.* European Transport Safety Council, Brussels.

FONTAINE, H. (1997) *Typological analysis of pedestrian crashes.* Journée d'Études sur les Crashes de Piétons, Paris, 12 September.

FORESTER, J. (1983) *Cycle transportation*. MIT Press.

GREIBE, P., NILSSON,P., AND ANDERSEN. K. (1998) *Urban Safety Management: Overview of Danish Experiences*. Vejdirektoratet Report No 37.

HERRSTEDT L. et al. (1994) *Safety of cyclists in urban areas – Danish experiences*, Road Directorate Report.

HERRSTEDT, L. (1997) *Planning and Safety of Cycles in Urban Areas*. Paper presented to International Conference on Traffic Safety on Two Continents, Lisbon.

INSTITUTION OF HIGHWAYS AND TRANSPORTATION (1997) *Transport in the Urban Environment*. London.

INSTITUTION OF HIGHWAYS AND TRANSPORTATION (1996) *Cycle-Friendly Infrastructure*. London.

INSTITUTION OF HIGHWAYS AND TRANSPORTATION (1991) *Reducing Mobility Handicaps, Towards a Barrier-Free Environment*. London.

INSTITUTION OF HIGHWAYS AND TRANSPORTATION (1990) *Guidelines for urban safety management*. London.

IRTAD (1999) International road traffic and accident database (OECD), Federal Highway Research Institute (Bast), Begisch Gladbach, February.

JENSEN. S. (1998) *DUMAS – Safety of Pedestrians and Two Wheelers.* Danish Roads Directorate Report 51.

LARSEN L.B. (1994) *The epidemiology of bicyclists' accidents*. Journal of Traffic Medicine, 22 1994, 27-31.

LAYFIELD, R., AND MAYCOCK, G. (1986) *Cyclists at Roundabouts*. Traffic Engineering and Control, June.

LEDEN, L. (1998) *Road Safety of Cycling Children – Effects of Road Design and Regulation*.
Lund Institute of Technology, Bulletin 74.

LEVELT, P. (1994) *Telematica: Kwetsbare Verkeersdeelnemars*. SWOV Report – 94-64.

LINES, CJ. (1995) *Cycle crashes at signalised roundabouts.* Traffic Engineering + Control Feb.

LONDON RESEARCH CENTRE (1998) *Annual Report*. LRC London. OECD (1998) *Safety of vulnerable road users.* Paris: Organisation for Economic Co-operation and Development.

MINISTRY OF TRANSPORT AND PUBLIC WORKS, NL (1996) *Towards safer roads, Opportunities to bring about a sustainably safe traffic system*. Transport Research Centre (AVV) of the Ministry of Transport and Public Works, The Netherlands.

OBERG, G., NILSSON, G., VELIN, H., WRETLING, P., BENTMAN, M., BRUNDELL-FREIJ, K., HYDEN, C., AND STAHL, A. (1996) *Single Crashes Among Pedestrians and Cyclists*. SNRTRI Report 799A.

OECD (1998) *Safety of Vulnerable Road Users.* Scientific Expert Group on the Safety of Vulnerable Road Users (RS7). Organisation for Economic Co-operation and Development, Paris.

OECD (1990) *Behavioural adaptations to changes in the road transport system*. Road Transport Research. Organisation for Economic Co-operation and Development, Paris.

PEDESTRIAN ASSOCIATION (1995) *Driven Indoors.* Pedestrian Association, UK.

SARTRE (1998) *The attitude and behaviours of European car drivers to road safety*. Part 1. Report on principal results. SWOV Institute for Road Safety Research, The Netherlands.

SCHOON, C.C. (1996) *Praktijkonderzoek zijafscherming voor vrachtauto's (Experimental research on side protection for trucks*). SWOV report R-96-24, Leidschendam, The Netherlands.

SCHOON, C.C. (1996) *Invloed kwaliteit fiets op ongevallen (Influence cycle quality on crashes).* SWOV report R-96-32, Leidschendam, The Netherlands.

SCHOON, C.C. (1994) *Fietsongevallen als gevolg van een mechanisch gebrek (Cycle crashes due to mechanical failures*). SWOV report R-94-46, Leidschendam, The Netherlands.

TOWLIAT, M. (1997) *Traffic Safety Problems for Pedestrians and Cyclists at Crossing Points.*
Lund Institute of Technology.

TREVELYAN, P. AND MORGAN, J. (1993) *Cycling in Pedestrian Areas*. Transport Research Laboratory Report 15.

WEISS, B.D. (1994) *Cycle related head injuries.* Clinics in Sport Medicine 1994; 13(1).

WERELE, H (1992) *Cycling in one-way streets: the Saarbrucken model.* Polizei Verkehr Technik 4/92, pp104-107, Germany.

WITTINK R. (1998) *The best road safety approach for pedestrians and cyclists is to integrate safety measures in a mobility plan*. Paper presented to Congress of the Safety of Vulnerable Road Users, KfV, Vienna.

WILKINSON, W., CLARKE, A., EPPERSON, B., and KNOBLAUCH R. (1994) *Selecting roadway design treatments to accommodate cycles*. Federal Highway Administration, Report No. FHWA-RD-92-073, Washington DC.