Pedestrians: needs, facilities and interventions

Overview of insights in literature

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Preface

This report gives an overview of pedestrian related information provided by a broad set of studies. The information is brought together in order to contribute to efforts that aim at an integrated insight into pedestrian quality. Those efforts are made at the European level by the COST 358 Pedestrians' Quality Needs (PQN) project and at the Dutch national level by the Dienst Verkeer en Scheepvaart (DVS). At both levels, it is recognised that safe mobility, comfortable and healthy walking in public space and quality of life of pedestrians are worthwhile objectives to aim at.

Information from more than sixty studies was analysed within the conceptual framework of a systems approach. This approach is basically used to distinguish between activities in the COST PQN project. Ultimately, the literature information in this report will be of use for work package 4 of the PQN project that will identify, among others, best practises and gaps in knowledge.

The reader should take into account the following two points. Firstly, the information in this report does not pretend to be comprehensive. Undoubtedly, relevant studies were performed by researchers that stayed beyond the limited dimensions of this literature study. Secondly, this report is a compendium rather than that it should read as a book or an article. Information from studies was broken into segments parallel to the systems approach. These segments are the respective chapters in this report. Consequently, passages and extracts from all those studies were allocated to the most applicable part of that conceptual framework.

All literature included in this report is physically brought together in a CD Rom. This allows the interested reader to go back to the source and to assess the context of the information from the individual study. The CD Rom contains both abstracts and full texts of the references.

The authors

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Introduction

Context
This literature overview shows results of studies that provide information on pedestrians. This information on pedestrians is brought together in the context of efforts that are made to describe pedestrian quality. Safe mobility, comfortable and healthy walking in public space and quality of life of pedestrians are worthwhile objectives to aim at. Dispersed knowledge and insights across countries deserve to be known. Collection of relevant information and insights allows identifying pedestrian needs and requirements that meet those needs. This identification is taking place within the framework of an integrated systems approach avoiding a too sectoral approach. This systems approach includes the conceptual framework for, among others, the COST 358 Pedestrians' Quality Needs (PQN) project and explicitly distinguishes the following set of main issues:

1. Identification of quality needs
2. Assess the importance of needs
3. Identification of requirements
4. Assess the current level of service
5. Assess compliance and satisfaction
6. Identification of compliance and satisfaction mechanisms
7. Identification of promising interventions
8. Assessment of potential pedestrian system output.

Pedestrian related insights that were selected from published studies are allocated to one of these main issues. It may occur that some insights have relevancy to more than one main issue. In those instances, the information is repeated.

Selection
The collection of information from literature inevitably has to be selective. The following principles in the selection process were followed. Firstly, information is considered relevant as far it is based on scientific studies. In practise, information is mainly taken from peer reviewed journals, and European projects and contributions to the European Transport Conferences. Within this, priority is given to studies that were carried out relatively recently. Finally, information from European sources is thought to be most relevant given distinct social and infrastructural conditions for pedestrians elsewhere. Nevertheless, part of the information from outside Europe might be highly relevant as far as this information refers to more general, continent-independent needs and requirements of pedestrians. Obviously, a clear line of demarcation cannot be drawn.

Categorising
As far as pedestrian related information based on thorough studies is available, this information needs to be categorised enabling a more systematic knowledge of insights. This report used two criteria for categorising available insights within each of the main issues mentioned above. The first one is of a more formal nature whereas the second one is more substantial in the sense of technical content.

The first, formal criterion describes information at different levels and refers to divergent aspects of life and mobility. In the literature overview, information is arranged according to the level at which road users take decisions: at the strategic level prior to getting into traffic, tactical decisions related to the route to be taken and operational decisions that are made while being on the route mostly related to traffic situations and interactions to other road users or physical conditions of the outside world. A fourth level is added to these three frequently distinguished levels, namely an existential level at the top of the strategic level. This level refers to basic decisions people take incidentally in their life such as where to live and where to work. A short but typically characterising description of those four levels is, from more abstract to the more concrete level, ‘being’, ‘going’, ‘travelling’ and ‘walking’.

The second information allocating principle uses aspects of walking that have a general relevancy in debates, policies and research. These aspects are safety, health or environment, getting efficiently to the chosen destination, comfort and convenience and a residual category of aspects mainly related to personal capabilities. These types of categories will be used within each of the four levels before mentioned.

This structure is applied as far as feasible. In some chapters we added a more general section when the information did not relate specifically to one of these themes.

Presentation

The information is presented by selecting relevant paragraphs out of the selected literature and allocating these to the applicable section. Each selected paragraph is followed by the proper reference (author(s), and if possible: year and page number). This enables to return to the full context of the study based on which the observation about pedestrians needs etcetera was based. A summary of each study is given in a separate document. The way the information is presented in this report has an enumerating character. It is not the aim to integrate the information collected in this stage arriving at a harmonised and synthesised overview of insights, apart from a short summarising paragraph. The nature of the activity is making an inventory rather than analysing the available information. The inventory provides in itself already relevant information: what main issues of the systems approach were predominantly addressed in scientific studies and what main issues were underexposed. An outcome of the overview may also be a better, empirically based feeling of the spread of studies and insights across pedestrians’ life spheres of being, going, travelling and walking.

1 Identification of quality needs

This chapter describes study results that provide insights into quality needs of pedestrians. This main issue as distinguished within the systems approach covers a whole set of conceivable sub-issues. These sub-issues are formulated as research questions in the context of the PQN project. There, available information is arranged according to those research questions. Here, the information selected from literature is arranged according to the criteria explained in the introduction.

It should be noted that authors discuss their studies rarely in terms of needs of pedestrians. Their scope usually is on factors conditioning or enhancing positive walking conditions or factors causing positive walking experience rather than on needs (requirements). However, those factors may reflect internal needs that lie behind the mechanism that makes a pedestrian positive about those external, 'environmental' factors. Therefore, this chapter includes studies that refer to factors that positively condition walking. It should also be noted that it is sometimes an interpretation of the researcher or even an assumption that specific factors contribute to the quality of the walking experience whereas the information is not necessarily based on studies among pedestrians.

1.1 Needs on the existential level

Evans & Norman ([17] 1998: 482) found that people, when asked to describe themselves in general terms, were able to categorise themselves in general terms as careful pedestrian or, in the negative cases, as less-careful pedestrians. A self-identity scale could be constructed using six items with an alpha coefficient of 0.81. The authors were inspired by earlier researchers (Biddle et al. 1987; Charng et al., 1988) who argued that people's self-identities, i.e. the labels people use to describe themselves, are important determinants of behaviour. The interesting result of the study of Evans & Norman is the empirically based finding that self-identity emerged as significant independent predictor of pedestrians behaviour (in this case: road crossing in different conditions) additionally to other variables out of the Theory of Planned Behaviour such as attitude and subjective norm. Their results suggest that respondents who view themselves as 'safe pedestrians' are more conscious of the dangers involved in certain road situations and, as a result, are less inclined to make potentially risky decisions ([17] Evans & Norman, 1998: 487). Although not literally a need, it can be indirectly concluded that pedestrians have a general notion of themselves as being more or less careful on their way. This notion reflects to some extent their way of being and the way they want to be.

The activity patterns of especially women have changed drastically in the last decades. These changes make it necessary that different movements are combined. The car is a more obvious mode of transportation than the bicycle. Bringing the kids the school is more often combined with commuter traffic ([6] AVVa).

Extensive information about pedestrian needs on this level of existential needs – e.g. on lifestyle – was not found in the studied literature. Here, more research is needed. More information is available about the needs on the strategic, tactical and operational levels.

1.2 Needs on the strategic level

Already the high intensity of walking points to a type of activity that is basic to human beings and is an essential part of their lives. Survey data from seven European countries show that 15-30% of all trips are made by walking. For short trips under 5km, the figures may rise to 40%. Generally, the number of daily walking trips is higher for women than for men, and it does not seem to vary much according to age, except for some countries where elderly people tend to walk more ([42] NTUA, 2001).

Pedestrians show moving patterns. These patterns point to a basic need for moving from one point to another for whatever reason or motive. *Mobility* can be said to be either a basic need or a substantial activity that immediately is connected to the necessity and desire to move. Pedestrians travel for particular purposes: going to work, to school, to shops, etc. But pedestrians can also use public roads for reasons others than travelling, such as playing, taking leisure walks, exercising and meeting other people ([42] NTUA-PROMISING, 2001). Whatever the purpose of their movements or trips, pedestrians require continuity of the network they are allowed to use.

Mobility evokes a broad range of activities performed on the pedestrian network, such as preparation of trips, performing trips, walking along, exercising and various forms of social interaction. These activities require further mobility needs. The PROMISING project has extensively and comprehensively listed those mobility needs. These needs are shown in deliverable 1 of the project in a table (pages 31-33) distinguishing between needs common to all pedestrians and special needs for the more vulnerable pedestrians. In fact, the PROMISE overview identifies requirements put on the design of roads and their environment and on traffic planning and management by pedestrians' moving patterns. All those needs and related requirements stem from the existential need to move as human beings.

Pedestrians can be assumed to minimise their physical efforts as far as their intention is to move from A to B and apart from running for exercise and walking along. To the extent that this is true, it has consequences for their strategic choices, tactical choices and operational choices. In tactical sense, pedestrians usually choose the shortest route and do not want to spend extra time on the trip. Taking the shortest route means that underpasses or pedestrian crossings may be considered as severe restrictions if not adequately located, as well as traffic lights if waiting for the green takes too long ([42] NTUA, 2001). In operational sense for example, it has consequences in crossing behaviour such as an intrinsic tendency to avoid detour at the micro level by crossing diagonally.

Virtually every trip by car and public transport is preceded and followed by some walking. Work-related trips are rarely made entirely on foot. People also walk when they go shopping and walking is a recreational means of transport (strolling). The dominant reasons for trips relate mainly to characteristics of the groups. Pedestrians who need walking aids restrict their trips to those that are urgent and essential (doctor, groceries etc.), and that trips ‘for fun’ have a subordinate position. For this vulnerable group public safety is a special consideration ([38] Methorst, 2003c: 46, 171).

Alayo (2002) presents ways of measuring pedestrian accessibility in urban environments and the paper discusses how urban form and the composition of the urban fabric (density and mix) influence the level of accessibility for any location within a city. The paper discusses different aspects in which accessibility can be considered: * Accessibility to and from a location; * Accessibility through a location, and * Accessibility as visibility or presence within the urban system (important for orientation and navigating through cities). The last aspect is more a requirement, but needs can be derived from it. The paper then demonstrates how these various types of accessibility can be measured by using a series of case studies from various cities, for which a new software tool was used ([4] Alayo, 2002).

Safety

Literature review indicated that environmental designs and urban forms could play a very crucial role in pedestrian travel behaviour. A proper design of facilities can encourage walking without compromising safety and convenience (Handy, 1996; Shriver, 1997 in: [54] Sisiopiku & Akin, 2003: 252).

Elvik (2000) addresses pedestrian insecurity in the context of a discussion of impact assessment and cost-benefit analysis. He argues that a number of impacts that are likely to be regarded as important for pedestrians (and cyclists) are not included in current impact assessments. ‘There is no doubt that a feeling of insecurity in traffic is a problem for many people’, referring to parents not allowing children to play outside if there is motor traffic in the neighbourhood and to older people who are often afraid to cross the road or do not walk outside at all if it is slippery during winter ([16] Elvik, 2000: 40).

Only half of the older respondents leave their house during dark hours, and these are mostly men and older people with a good health ([9] Bernhoft & Carstensen, 2008: 86).

Pedestrians are not the only groups on the streets. The reality is that they have to share the streets (and pavements) with drivers, cyclists, roller skaters etc. These other groups can influence the perception of safety of the pedestrians. Older pedestrians find it dangerous to walk when there are cyclists or roller skaters on the pavement ([9] Bernhoft & Carstensen, 2008: 86). In the younger group a significant higher proportion of men (than women) feel troubled by cyclists and roller skaters on the pavement ([9] Bernhoft & Carstensen, 2008: 87).
A tunnel is an example of another route characteristic. More women than men find it dangerous to walk in a tunnel. Younger women appreciate requirements as street lighting more than younger men and feels more troubled by parked cars when crossing the road ([9] Bernhoft & Carstensen, 2008: 87). The needs that can be derived from these requirements are the needs for visibility and conspicuousness.

Social security

Although the concept of ‘security’ is being used referring to traffic safety (e.g. see Elvik), security as a concept is also being used to designate social security. Literature is scarce as far as this social security for pedestrians is concerned. It is recognised that security features can have important effect on the pedestrian perception of the overall quality of the street environment ([21] Henson, 2000: 27). It does not necessarily mean that security is considered as a basic need. Most likely, security is a conditional factor that provides a relatively low degree of conscious positive experience, whereas the absence of it gives rise to a higher degree of conscious negative experience.

Health, environment
Walking is a form of physical exercise and, hence, healthy ([20] Gunnarsson (ed.), 2001: 3; 7). The net effects of physical exercise and exposure to pollution are likely to be favourable, that is walking improves your health despite the fact that you are sometimes exposed to pollution when walking for walking ([16] Elvik, 2000: 39, referring to Pearce et al., 1998).
Economy: includes factors associated with monetary cost and the inconvenience of perceived delays in journey time; the latter being related to the risks the user is willing to incur ([49] Penna de Araujo & Gnecco de Camargo Braga, 2008: 542).
Walking and cycling are essential modes of travel for many in low and middle-income countries, and are also promoted for their environmental, economic and health benefit ([27] Kwan & Mapstone, 2004: 305).
In principle, the need for healthy behaviour could play a relevant role in mode choice. However, walking as an option receives little attention in studies and literature on mode choice. Obviously, distances are mostly too long for people to really consider the walking option.

These statements not necessarily point out that pedestrians have an intrinsic need for walking from a health enhancing point of view. Walking might be healthy in case it is not goes together with a too high pollution level. Discussion in literature is in terms of assuming this need rather than in terms of empirically demonstrating the need.

Comfort and convenience
Factors that contribute to the walking experience are among others comfort factors like weather protection, climate control, arcades, transit shelters and other pedestrian amenities ([21] Henson, 2000: 27). Additionally to comfort factors, Henson discusses convenience factors. Convenience factors referred to by Henson include walking distances, sidewalk ramps, pathway directness and directional signing. Convenience includes factors which make the act of walking easy and uncomplicated ([49] Penna de Araujo & Gnecco de Camargo Braga, 2008; [21] Henson, 2000). Comfort and convenience factors are discussed by Henson in terms of environmental factors that contribute to the walking experience rather than as needs of pedestrians. However, factors positively contributing to the walking experience may reflect pedestrian needs to a high extent.
The walking distance is an important factor when people have to decide if they will walk. ‘Bringing back proximity to schools, workplace, service and other amenities’ can reduce automobile traffic ([20] Gunnarsson (ed.), 2001: 3).

Pedestrian comfort also includes waiting time. Important is the unpleasantness of waiting conditions and the uncertainty of the waiting time (MVA et al., 1987 in: [26] Keegan & O’Mahony, 2003: 891). Antonides et al. (2000 in: [26] Keegan & O’Mahony, 2003: 891) found that information on the expected duration of waiting time reduced the overestimation of waiting time.

The present study shows the importance of giving older pedestrians an even surface to walk on. When it comes to walking, an uneven surface on the pavement does not to the same degree prevent young people from walking fast, but it can be the cause of falling for older people, who have problems moving or have reduced eyesight ([9] Bernhoft & Carstensen, 2008).

Skills/abilities

A feeling of insecurity in traffic can be a serious problem for many people. This can stop them from going out. 'On the other hand, it seems likely that an excessive feeling of security (a false sense of security) may cause accidents. Road users feel too safe and underestimate the risks involved in many situations. Most road users want to feel safe, and when they do so, they tend to think that the risk of accident is negligible' ([16] Elvik, 2000: 40).

In general, older people become less agile and their reaction time increases. The age-related deficiencies appear at different ages for different people, and people differ in their awareness of their own deficiencies. Older people are also more fragile (Bernhoft & Carstensen, 2008: 83-4; [47] Oxley et al., 1997: 839), their vision is poorer (especially in low illumination), they have lower mental status scores, a greater need for help in activities of daily living and more likely to have histories of stroke, fracture, and diabetes, slower information processing and living in public housing, ([28] Langlois et al., 1997: 395; [33] Luoma et al., 1996: 381; [48] Oxley et al., 2005: 962).

Furthermore, older people underestimate their age-related loss on performance. 'For example, Holland and Rabbitt (1992) argued that, because of reduced information processing capacity, older adults may be less efficient than younger adults at monitoring their own performance, less aware of their mistakes, or less able to remember making mistakes. The authors have also found evidence of this in earlier work (Oxley et al., 2001 in: [48] Oxley et al., 2005: 970).
The extent to which people are drivers can also be important for their traffic perception skills. 'There is some evidence that skill differences between drivers and nondrivers may account for differences in accident rates (Carthy et al., 1995), though this study found no age or gender effects' ([23] Holland & Hill, 2007: 224-5).

A problem especially for elderly pedestrians is falling down caused by slippery, uneven surface, especially in winter climate ([20] Gunnarsson (ed.), 2001: 11).

'Children have limited capacity to understand the complexity of the traffic environment' ([20] Gunnarsson (ed.), 2001: 10). 'Sandels (1968 in: [20] Gunnarsson (ed.), 2001: 11) have clearly demonstrated that most of the children up to an age of 8-9 years are unable to understand traffic rules, and they may not yet know the difference between right and left. They also feel anxiety for motor traffic outside their homes and on school routes.

Summarising

The above mentioned passages seem to point to some strategic needs of pedestrians. Strategic needs are needs that pedestrians generally have before they get into traffic. The following observations are to be kept in mind when concluding to the existence of those strategic needs.

(1) In literature, implicit rather than explicit reference is usually made to basic needs of pedestrians.
(2) Basic needs such as the need for safety are assumed rather than empirically demonstrated.
(3) Part of the basic, strategic needs are likely of a dissatisfying nature rather than of a satisfying nature. The most striking example is safety/security: insecure situations discourage

(specific groups of) pedestrians or bring forward negative experience rather than that safe traffic situations encourage pedestrians to walk or enhance positive experience. Stated in a different way: the need for avoiding unsafe situations is likely greater than the need for walking in safe traffic situations.

Needs at the strategic level that can be said to appear, more or less explicitly characterised as needs, are the following:
- need for safety
- (need for security)
- need to behave healthy
- need for comfort and convenience
- need to recognise one's shortcomings and to behave accordingly.

These needs have different degrees of relevancy for subjects. As far as insights on a hierarchy of needs are available, these will be discussed chapter 2. It might be assumed that walking safely is a primary need whereas convenience might be important when this need for safety is met.

1.3 Needs on the tactical level

In the Netherlands, pedestrians, cyclists and moped riders (and all modalities equated with these in the law) are not permitted to use the trunk roads and motorways. On the other hand, pedestrians have more freedom in their choice of route than bicycles and motorised vehicles, because they can also used non-paved paths ([38] Methorst, 2003c: 49).
Willis et al. (2002) describes the development of a microscopic model of pedestrian movement (PEDFLOW) that can simulate the effects of environmental layout on how pedestrians negotiate the walking environment. Its approach is novel in two important regards: first, unlike most current models of pedestrian movement, PEDFLOW takes an agent-based approach, allowing the characteristics of individual 'virtual' pedestrians to be assigned and varied as required; second, the development of the model will be informed by empirical studies of how pedestrians behave 'in real life'. On their own, these studies will enhance current understanding of which factors influence individuals' decisions to walk a certain route and also, through 'before-and-after' studies, which measures are successful in achieving desired changes in pedestrian mobility and walking behaviour ([65] Willis et al., 2002).

Safety
'With respect to turning vehicular traffic, half of the respondents complained that turning vehicles do not respect pedestrians that attempt to cross at signalized intersections during green. This has been, also, verified by field observations. In most cases pedestrians and right- or left turning vehicles share the same green phase with pedestrians. This situation is cited as a reason for pedestrians choosing to cross the road at locations other than signalized intersection crosswalks during green ([54] Sisiopiku & Akin, 2003: 271).
Younger respondents more often return to the pavement when they are crossing the streets than older pedestrians. This last group doesn't think it is safe to return and they don't want to confuse other road users. Younger respondents are more confident about their competences. They think they have a good overview and they do 'not doubt their own behaviour' ([9] Bernhoft & Carstensen, 2008: 89).

Older respondents seem to be more influenced by the fact that an action is illegal and they more often give this reason for refraining from an act than the younger respondents do ([9] Bernhoft & Carstensen, 2008: 92).

When it comes to feeling comfortable as a pedestrian, both the older road users and the group aged 40–49 appreciate pedestrian crossings and signalized intersections most, and both groups find it most dangerous to cross a road without a pedestrian crossing. However, a significantly higher proportion of the older respondents appreciates signalized intersections, finds it dangerous to cross a road without a pedestrian crossing and finds it dangerous to walk, when there are cyclists or roller skaters on the pavement. The younger group, on the other hand, more often finds street lighting important. This corresponds to the fact that more of the younger than the older respondents go out during dark hours ([9] Bernhoft & Carstensen, 2008: 86).
Safety includes factors which reduce conflict between pedestrians and vehicles ([49] Penna de Araujo & Gnecco de Camargo Braga, 2008: 542).
A higher proportion of older women would choose a route with signalized crossings and a higher proportion of younger women appreciate signalized crossings more than younger men ([9] Bernhoft & Carstensen, 2008: 87).
In the study of [54] Sisiopiku and Akin (2003) the pedestrians appreciated the midblock crosswalks and 83% of the survey respondents said that the presence of a midblock crosswalk affected their decision to cross at a specific location. 'The same is true with the presence of a pedestrian traffic light for 74% of the survey respondents ([54] Sisiopiku & Akin, 2003: 269).
A tunnel is an example of another route characteristic. More women than men find it dangerous to walk in a tunnel. Younger women appreciate street lighting more than younger men and feels more troubled by parked cars when crossing the road ([9] Bernhoft & Carstensen, 2008: 87).
The study of Bernhoft & Carstensen (2008) showed that 'the older respondents appreciate pedestrian crossings, signalized intersections and cycle paths significantly more than the younger group. To a larger extent they feel that it is dangerous to cross the road where these facilities are missing' ([9] Bernhoft & Carstensen, 2008: 92).

For elderly people (and women) in particular, public safety plays an important role in route choice, especially during the hours of darkness ([38] Methorst, 2003c: 49).

Fastest route/no delays or detours
Health and age plays a role in determining the routing. Older road users with poor health cross the road away from a crossing facility more often than others with poor health conditions. They do this to avoid a detour ([9] Bernhoft & Carstensen, 2008: 88).
Younger people more often cross when the light is red. The reason is that there is little or no traffic and/or there is a good overview. Again, the younger more often do it, if they are in a hurry ([9] Bernhoft & Carstensen, 2008: 89).
A study by Tanaboriboon and Jing (1994 in: [54] Sisiopiku & Akin, 2003: 252)) compared signalized intersection pedestrian crossings to overpass and underpass counterparts and concluded that users preferred the signalized crossings to the overpass or underpass crossings. The authors also reported that the pedestrian crossing compliances with pedestrian signal at two study locations were 70% and 57% ([54] Sisiopiku & Akin, 2003: 252).
Waiters at signalized pedestrian crossings were asked why they waited. 'Danger/fear/safety' was cited as a reason for 45% of the sample, 'high traffic volume' was mentioned by 21% and 20% of the sample always waited ([26] Keegan & O'Mahony, 2003: 894). The walkers were

asked what their main reason was for not waiting. 32% thought it was safe to cross, 31% of the sample was in a hurry/late/never wait/habit/hate waiting and 20% was impatient ([26] Keegan & O'Mahony, 2003: 897).
How often people cross a street has an impact on how safely they act. 'Occasional users of crossing facilities appear to be more conservative in their crossing choices. For example, only 18% of occasional users admit to cross frequently at nondesignated locations, compared to 34% of daily users' ([54] Sisiopiku & Akin, 2003: 268).
The pedestrians experience delay at a signalised crossing ([26] Keegan & O'Mahony 2003: 896). The 'walkers' (during a red light) were asked what their reason was for not waiting. 32% thought is was safe to cross, 31% was in a hurry, late, never wait, habit or hate waiting and 20% was impatient ([26] Keegan & O'Mahony, 2003: 897). Seventeen percent considered the length of time they waited to be too long.
Other studies also confirm time-related reasons for unsafe crossings. Forsythe and Berger (1973) found that 'a need to hurry or a desire to keep moving was the main reason behind the lack of compliance with pedestrian signals ([54] Sisiopiku & Akin, 2003: 252). The main reason on which pedestrians make a decision to cross at a non-designated crosswalk is convenience (42%) while time-savings were of major importance to 27% of the respondents ([54] Sisiopiku & Akin, 2003: 268-9).

Pedestrians who use walking aids will avoid detours as much as possible because they take a lot of energy ([7] AVVb).

With respect to route choice, pedestrians have a clear preference for the shortest route. This preference is quite far-reaching. They are prepared to leave the paved paths for this ([38] Methorst, 2003c: 49, 172). Pedestrians also have a preference to walk on the same side of a sidewalk as the destination ([38] Methorst, 2003c: 172).

Research to the use of shopping routes showed that 84% of the people choose the shortest route, 8% doesn't know another route and 12% choose the route because of its attractiveness (Voet-gangervereniging01).
People have the urge to cross the street first and then walk in the direction of their destination. This preference is not facilitated by crossing facilities and is therefore risky ([6] AVVa).

Knowing what to expect
One-third of the younger respondents but only 7% of the older respondents admit to cross as a pedestrian, when the light is red. This is most often done (by both age groups) when there is only little or no traffic and/or if there is a good overview. Again, the younger more often do it, if they are in a hurry ([9] Bernhoft & Carstensen, 2008: 89).
Reducing uncertainty is relevant in the case of signalised pedestrian crossings and in particular the uncertainty of waiting times. A large part of the disutility is associated with the likely duration of the 'red man' signal. The aim of the countdown unit is to eliminate this uncertainty by displaying accurate information about waiting time ([26] Keegan, O'Mahony, 2003: 891).

Skills/abilities

In general, the study shows that the older group claims a more cautious behaviour ([9] Bernhoft & Carstensen, 2008: 92). Within the group of older pedestrians men are more secure about their competences than women ([9] Bernhoft & Carstensen, 2008: 89).

The abilities and skills of a pedestrians and someone's own perception of it is also important. 'Safe pedestrian behaviour requires a combination of well developed skills to allow the individual to assess complex traffic situations, and to choose and execute appropriate responses' ([47] Oxley et al., 1997: 846). Younger people do not doubt their own behaviour. Older pedestrians act in a certain way because it makes them feel safer. They express more often doubts about their own abilities ([9] Bernhoft & Carstensen, 2008: 92). There are also differences between older men and women. 'Older women more often express a need to be safe and have doubts about their own abilities, while older men more often indicate that they feel sure about their own estimations of traffic ([9] Bernhoft & Carstensen, 2008: 92).

Pedestrians who need walking aids can't deal with height differences. They will avoid ramps ([7] AVVb).

Physical discomforts of pedestrians who use walking aids have a big influence on the route choice ([7] AVVb).

People with functional limitations need to know whether there might be awkward obstacles on their route. The more serious the limitation, the more difficult it is to deal with any obstacles and barriers, and the more trouble people take to ensure that they know what they will encounter on the route. The importance they attach to that knowledge correlates largely with the perceived seriousness of the functional limitation ([38] Methorst, 2003c: 49).

Convenience/comfort

Comfort: includes factors which promote well-being and a feeling of comfort in the pedestrian when using the crossing. Other studies also confirm time-related reasons for unsafe crossings. Forsythe and Berger (1973) found that 'a need to hurry or a desire to keep moving was the main reason behind the lack of compliance with pedestrian signals ([54] Sisiopiku & Akin, 2003: 252). The main reason on which pedestrians make a decision to cross at a non-designated crosswalk is convenience (42%) while time-savings were of major importance to 27% of the respondents ([54] Sisiopiku & Akin, 2003: 268-9).

Pedestrians disapprove of the use of warning pedestrians signs (a sign that displays the message 'cross only when traffic clears') at midblock locations. This sign often confuse or frustrate pedestrians ([54] Sisiopiku & Akin, 2003: 271).

A problem for pedestrians is 'narrow and crowded passages caused by too narrow pavements and walkways (also mixed with bicycles), or by obstacles and barriers on the pavement and walkways, e.g. parked cars, poles, rubbish bags, traffic signs, advertising signs, construction material ([20] Gunnarsson (ed.), 2001: 12). Pedestrians require an obstacle-free pavement or walkway because they need convenience.

Another problem is the 'poor information on current position, important destinations, safe walking routes etc. caused by unclear signs, lack of landmarks' ([20] Gunnarsson (ed.), 2001: 13). Pedestrians need that information.

Pedestrians also require that the sidewalk is clean. No mud, splash, puddles, dog mess, trash or litter on the pavement. Besides that (especially) older pedestrians need resting seats and meeting places. This also has to do with the need for convenience and comfort.

Pedestrians who needs aid walking (walking stick, walker) will choose the route with the least amount of resistance. This doesn't need to be the shortest route but it is the most even, the least risky and the route with the most pause possibilities ([7] AVVb).

Pedestrians who need walking aids will preferably cross at signalled crossings. But they are afraid that the light turn red to soon ([7] AVVb).

Summarising
The above mentioned paragraphs seem to point to a set of tactical needs of pedestrians. Tactical needs are needs that pedestrians have when they are in traffic and they have to make a decision, for example with regard to route, where to cross the street etc. The difference with operational needs is sometimes small. Whereas tactical needs have to do with making deliberate choices, operational needs are related to more unconscious decisions. Tactical behaviour is of a more rational rather than automatic nature.

Needs at the tactical level that can be inferred from literature search so far are the following:
- need for safe behaviour
- need for unambiguousness (meanings; what is acceptable)
- need to avoid conflicts with other road users (conflict avoidance)
- need for comfort and convenience
- need for continuity
- need for efficient route (shortest route; fastest route)
- need to be able to predict (enabling informed decisions).

Needs can be competitive. The need for convenient and safe walking may compete with the need for continuous and efficient (meso) route and (micro) path choice. A convenient route might be a route with unsafe elements. Pedestrians may accept the negative aspects of inconvenient route aspects as far as that route provides less loss of time and energy. Here, the time saving criterion outweighs the convenience related criterion. This weighing of criteria one against another will be pedestrian dependent.

Safety on the tactical level has different aspects. For example it is important when and where pedestrians cross the street. This can be a conscious decision. Are there any crossing facilities and does the pedestrian have enough time to cross the street? As far as the facilities are not safe, pedestrians will either tend to choose other places to cross the street or accept risk by using the less safe option.
The need for safety is related to the need for unambiguousness. This holds both for the meaning of signs and operations such as flashing traffic lights and for the consciousness of what is legally acceptable. This is more important for older than for younger pedestrians.

Another important tactical need of pedestrians is the need for the fastest or shortest (i.e. time saving) route without detours or delays. Additionally, many pedestrians want to keep on walking without delays. This may be an important aspect in deciding which route to take. Related but different needs can be said to be continuity and the need for a route with the least amount of effort or loss of energy for the pedestrian.

1.4 Needs on the operational level

In their analysis of factors influencing pedestrian accessibility, Leeds ITS (2004 in: Heuman et al., 2005: 6) found the following factors to be potentially the most important:

- levels of street lighting;
- number of roads crossed along a route;
- frequency of detours along a route;
- widths of footways;
- evenness of pavements;
- speed of traffic;
- volume of traffic;
- number of cyclists encountered; and
- cleanliness of pavements ([22] Heuman et al., 2005: 6).

The mentioned factors are requirements, but needs can be derived from them. The needs will be explored further below.

Safety

Safety is an important operational need especially when pedestrians are crossing the street. Pedestrians have a need to feel safe then. Apparently older people have a stronger need to feel safe. The results of a questionnaire showed that a higher proportion of the older pedestrians use the facilities available ([9] Bernhoft & Carstensen, 2008: 92). Older pedestrians find it dangerous to cross a street on foot where there is traffic turning and where there are many cyclists ([9] Bernhoft & Carstensen, 2008: 87).

Pedestrians have trouble crossing wide, multi-lane streets. Especially when there is heavy traffic volume and high vehicle speed. In these cases pedestrians need crossing facilities to cross safely. Multi-lane streets occur more regularly in countries outside Europe; however, also pedestrians in Europe have to cross wide multi-lane streets.

'Safety is provided by separation of pedestrians from vehicular traffic' ([21] Henson, 2000: 27).

'As pedestrians often compete with bicycles for the same space, the subjects were also asked to provide their input regarding safety issues that may result from this type of interaction. Fifty-nine percent of the users (pedestrians) were not concerned with the interaction between pedestrians and bicycles and did not perceive bicycles as a safety risk factor to pedestrians that cross at designated locations' ([54] Sisiopiku & Akin, 2003: 271). This research was done is the United States. Probably less people ride bicycles compared to Europe. By consequence, it might be expected that interaction between pedestrians and cyclist is more intensive in some European countries and that a higher proportion of pedestrians is concerned with the interaction.

Good overview
An important task of a pedestrian is to cross the street or intersection. This can be complicated by for example dense traffic, the width of the street ([9] Bernhoft & Carstensen, 2008: 84), two-directional traffic or when a decision needs to be made quickly ([48] Oxley et al., 2005: 962).
People cross the streets where it is not allowed because they think they have a good overview of the traffic and/or only sparse traffic is being present ([9] Bernhoft & Carstensen, 2008: 87-8).
Older people have difficulties with overlooking traffic from various directions in the same time (Carthy, Packham, Salter & Silcock, 1995 in: [9] Bernhoft & Carstensen, 2008: 84).

Being quickly at destination
Being 'in a hurry' is an important reason for crossing the road away from a crossing facility or crossing when the light is red ([9] Bernhoft & Carstensen, 2008). There are differences between older and younger groups. 'One-third of the younger respondents but only 7% of the older respondents admit to cross as a pedestrian, when the light is red ([9] Bernhoft & Carstensen, 2008: 89). Obviously, this proportion of non-conformity to rules is location-dependent and country-dependent.
The distance of the crosswalk to the desired destination is a major crossing choice determinant for the vast majority of pedestrians surveyed in the study by Sisiopiku & Akin (2003). If the crosswalk is too far from the destination people will not use it. Therefore, pedestrians have the need to cross diagonally.

Sidewalks
A problem that pedestrians have is the lack of walkways caused by improper traffic planning and design, lack of investments in walking-friendly infrastructure ([20] Gunnarsson (ed.), 2001: 12). Pedestrians need sidewalks to reduce the chance of conflicts with other road users.
But pedestrians also need a *good* sidewalk to walk on. A higher proportion of the older pedestrians find the presence of a pavement on their route most important ([9] Bernhoft & Carstensen, 2008: 86). The poor state of a sidewalk provokes the explicit displeasure of pedestrians (SECTRA 1998 in: [49] Penna de Araujo & Gnecco de Camargo Braga, 2008: 555; [51] Redmon, 2003: 28). It is also important that the sidewalk is wide enough ([21] Henson, 2000: 28).
Older respondents who do not cycle or who do not drive a car (more often women than men) appreciate places without high curb stones ([9] Bernhoft & Carstensen, 2008: 86).
'Disabled persons have difficulties with high kerbs, steps and slopes' ([20] Gunnarsson (ed.), 2001: 12). They need sidewalks that are adapted to their specific needs.

Facilities for pedestrians should be looked after. Pedestrians can't use sidewalks if there are big irregularities and the surface is not even ([36] Methorst, 2003a: 9).

Enough time to cross
A major concern of pedestrians is that with signalized crossings they do not have enough time to cross the street ([12] Carsten et al., 1998: 213). The malfunctioning or improperly timed signal is also one of the most frequent complaints received by public agency traffic engineers in the United States. 'Upon investigation, however, the signals in question are found to be operating as intended' by the engineers ([61] Yauch & Davis, 2001: 32).
It is especially important that children have enough time to cross the street. For the majority of pedestrians the time is more than adequate, but children need more time ([61] Yauch & Davis,

2001: 34). The youngest children are the slowest (3.16 seconds), the 8 and 9 year olds faster (2.84) and the 11-12 years olds fastest (2.77 seconds) ([13] Connelly et al., 1998: 446).
Older people as well have not enough time to cross the street. 81% reported insufficient time to cross ([28] Langlois et al., 1997: 395). The time they have to cross the street is not sufficient because older people walk slower ([61] Yauch & Davis, 2001: 34; [29] LaPlante & Kaseser, 2004: 38; [18] Fitzpatrick et al., 2007: 34-5; [47] Oxley et al., 1997: 841). Less than 1% of the New Haven pedestrians aged 72 years and older had a normal walking speed ([28] Langlois et al., 1997: 395).
Also pedestrians who are in a wheelchair of have difficulty walking may not have enough time to cross the street ([61] Yauch & Davis, 2001: 34). The level of the crossing is also important and the width of the street is also important for physical disabled pedestrians.
Not only special groups do not always have enough time to cross the street. 'A significant portion of pedestrians take 10 or more seconds to cross a two-lane road in the UK, while mean values of around 10 s have been observed in The Netherlands (Davies, 1992; Levelt, 1992 in: [12] Carsten et al., 1998: 214). This compares with the minimum values of 6 s of green time for pedestrians on the standard UK signalized pedestrian crossing (pelican crossing) on a typical two-lane road (Department of Transport, 1995 in: [12] Carsten et al., 1998: 214). The context of these findings has to be taken into account here. Roads are not everywhere as wide.
Older people also have difficulties in judging safe gaps in traffic, especially under complex conditions. Oxley et al. (2005) also revealed that old pedestrians took more time to make their decisions and Oxley et al. (1997) found that older pedestrians delayed before making their first step forward after the rear of the last vehicle had passed them. Therefore older people need larger gaps in traffic and aids for judging safety or convenience of the gap.

Unambiguous signs
Pedestrians disapprove of the use of warning pedestrians signs (a sign that displays the message 'cross only when traffic clears') at midblock locations. This sign often confuses or frustrates pedestrians ([54] Sisiopiku & Akin, 2003: 271).
It is important that children understand pedestrian signals ([61] Yauch & Davis, 2001: 35). Young children are more easily distracted, less able to sustain attentions, and less efficient at searching their visual field (Akhtar and Enns, 1989; Malek et al., 1990; Shinar, 1978 in: [13] Connelly et al., 1998: 444). This is also true for shoppers, tourists and other groups that do not walk for travelling.
Physically disabled pedestrians, seniors who may have physical conditions that restrict their sight, hearing and ability to walk may have trouble understanding the pedestrian signals ([61] Yauch & Davis, 2001: 35).
For blind pedestrians there are special signals. 'In the most commonly used signal, a repeating "cuckoo" is used for crossings that run in a north-south direction and a repeating "chirp" is used for crossings that run in an east-west direction'([8] Bentzen et al., 2004: 20). But blind pedestrians have difficulties remembering which sound is associated with which direction, or they may not know in which direction they are travelling ([8] Bentzen et al., 2004: 20).
People have the need for understandable and detectable signals and they need the abilities to comply. The complexity of a situation is a dyssatisfier.

Skills/abilities

There are different tasks involved in crossing the street. Pedestrians have to look left and right, stay on the zebra crosswalk, wait on the curb until the light turned green and they shouldn't enter the crosswalk after the light had switched to the orange signal ([11] Bungum et al., 2005: 272). It is also possible that they have to push a button to register their demand manually. Many pedestrians do not bother with this ([12] Carsten et al., 1998: 213; [61] Yauch & Davis, 2001: 34). Pedestrians have to assess traffic ([9] Bernhoft & Carstensen, 2008: 84) and cross the street within the allotted pedestrian crossing time ([29] LaPlante & Kaseser, 2004: 32).

And if there are no lights the pedestrian has to select gaps. 'Clearly, the abilities to perceive and integrate speed and distance information of approaching vehicles accurately and to select a gap large enough, taking account of any physical limitations, are crucial components of safe road-crossings' ([48] Oxley et al., 2005: 962).

Important is the view and perception of oncoming traffic and setting safe distance gap thresholds. Children have more problems with these skills. 'A young child's view and perception of oncoming traffic may be affected by their height restricting their range of view, resulting in less than optimal surveying of traffic from behind a parked car or when obstructed by utility poles, trees, or buildings' ([13] Connelly et al., 1998: 444).

Children have more difficulty in judging speed and distances than adults even though this is also complex for experienced adults. 'In summary, the present findings reveal that pre-adolescent school-age children, particularly those aged below 10 years, have relatively poor skills at reliably setting safe distance gap thresholds, and thus do not consistently make safe crossing decisions. Their capacity for making such decisions safely progressively declines as vehicle approach speeds exceed 55 kph' ([13] Connelly et al., 1998: 450).

Older people also have difficulties in judging safe gaps in traffic, especially under complex conditions. This may be due to age-related declines in perceiving objects in motion (Carthy et al., 1995; Cavallo and Laurent, 1988; De Lucia et al., 2003: Staplin and Lyles, 1991 in: [48] Oxley et al., 2005: 962), estimating the time-of-arrival of an oncoming vehicle at the crossing point (Schiff et al., 1992; Scialfa et al., 1991 in: [48] Oxley et al., 2005: 962) and/or compensating adequately for age-related declines in walking speed (Lee et al., 1984; Yanik and Monforton, 1991 in [48] Oxley et al., 2005: 962).

There are other problems with crossing the street. 'A good deal of evidence suggests that pedestrians do not consistently look for turning vehicles travelling on an intersecting path'. This has to do with their concentration and knowledge of what tot expect. There is an overrepresentation of left-turning vehicles in pedestrian crashes in crosswalks ([24] Van Houten et al., 1999: 30). 'When Van Houten and Malenfant examined pedestrians' observing behaviour, they found the percentage of pedestrians looking for turning vehicles was highest for vehicles starting to turn ahead of the pedestrian, lower for vehicles starting to turn beside the pedestrian and lowest for vehicles starting to turn behind the pedestrian. These data also show motor vehicle-pedestrian conflicts occur less frequently when pedestrians look for turning vehicles ([24] Van Houten et al., 1999: 30).

There are differences between men and women. Women generally feel that a harmful outcome is more likely than man ([23] Holland & Hill, 2007: 233). It is also true that women take fewer risks ([23] Holland & Hill, 2007: 226).

'Persons with disabilities have special problems that vary depending on the types of handicap, e.g. moving quickly, walking longer distances, using steps, reading traffic signs and other information, avoiding obstacles, and hearing approaching cars. Mentally disabled people have difficulty in orienting themselves, perceiving risks, and understanding of signs and traffic information. Another group that is affected by traffic emissions is allergic an asthmatic persons, who get breathing problems and eye irritations' ([20] Gunnarsson (ed.), 2001: 11).

Drunk pedestrians
The impaired judgement and slower reaction time of intoxicated pedestrians may make them more likely to be involved in impacts of greater physical force: they may be slower to avoid an oncoming vehicle, more likely to walk into the path of a moving vehicle, and more likely to fall asleep in or near the roadway ([40] Miles-Doan, 1996: 24).
Drunk pedestrians depend on the forgiving nature of the environment and other road users ([57] SWOV, 2007a: 2).

Summarising
The above mentioned paragraphs point to a set of operational needs of pedestrians. Operational needs are needs that pedestrians have when they are in traffic having already decided what route to take or where to cross the street. Generally, these needs refer to more concrete behaviour that usually is prompted more or less routinely.

Needs at the operational level are the following:
- need for safe crossing facilities
- need for crossing facilities present at convenient locations
- need for enough time for crossing at signalised crossings
- need for large enough gaps
- need for detectable and understandable signs
- need for crossing diagonally / need for absolutely the shortest walk / need to minimalize efforts

1.5 In general

People involve in their choice to walk, instead of using other means of transportation, two kinds of arguments: person dependent and spatial aspects.
Examples of person dependent arguments are:
- Where is the destination: is it within the neighbourhood, then there is a big chance that people will walk.
- The motive for moving: work related movements are hardly done by foot. With other motives people don't have such a strong preference.
- The attitude towards safety: when people think it is not safe to walk (social security and traffic safety) people will most likely not walk. This is especially true for women, elderly and people with a disability.
- The suitability of walking: when alternatives (bicycling or car) are found more suitable people will not walk. It is also important what the time budget is that people assign to certain movements (see below).
- Availability of other ways of movement: when someone has alternatives for walking they will use these alternatives. Walking is not seen as the ultimate way to get somewhere.
- Spatial aspects are:

- The suitability of the environment for walking, orientation possibilities and safety: predictability and reliability are also important. Orientation and safety are connected to that. When someone can find the way, they will feel safe.
- The availability of attractable spots: the availability of shops, services and other crowd pullers and the distance to and between these spots are essential.
- The attractiveness of the environment: only works when there are suitable connections and there is enough safety.
- Comfort: perception of comfort is important, especially for elderly and people with a disability. When people feel that there is a lack of comfort (for example people think they will get wet or run in to obstacles) this is a decisive argument not to walk.

'Voetstappen in de sneeuw' shows that people connect time budgets to different kind of movements. People have an individual view of how much a movement to for example a shop may take. When people can walk to the shop in that time, then walking is an option, otherwise not ([6] AVVa).

The sustainable safety approach in The Netherlands has five principles. These principles can be compared to needs. Although the approach is not just for pedestrians they can be applied to them as well. The first principle is the functionality of roads. Roads should have one function. The second one is the homogeneity of masses, speeds and/or direction. The forgiving nature of the environment and other road users is the third principle. Recognisability of the design of the road and the predictability of the road and behaviour of other road users is the fourth principle. The last principle is that road users can assess their capabilities ([58] SWOV, 2007b: 1).

The following clusters of needs (in the terminology of PROMPT: problem areas) are distinguished:

- needs for of physical and social space
- needs for equipment and services in outdoor spaces
- need for sound interference with vehicles
- needs for support by and connection to other modes of transport
- need for natural, architectonic and psychological features of the environment
- need for good environmental performance.

([50] Source: http://virtual.vtt.fio/virtual/prompt/english.pdf)

2 Assessment of needs

In this chapter it will be assessed how important the various identified needs (chapter 1) are in an absolute and relative sense.

2.1 Existential needs

For the time being no information.

2.2 Strategic needs

There are differences between men and women and age categories in which need they find more important. Some of these differences are mediated by factors relating to travel pattern.
A significantly higher proportion of the older respondents, who do not cycle or who do not drive a car – more often women than men – answers that they appreciate long green phases and places without high curb stones, whereas a higher proportion of older respondents, who have still got their driving licence – more often men than women – appreciates good street lighting. But fewer women go out during dark hours and might therefore not find the statement very relevant ([9] Bernhoft & Carstensen, 2008: 86-7). Appreciating long green phases refers to the need to behave environment friendly and street lighting for the need to be safe.

2.3 Tactical needs

One-third of the younger respondents but only 7% of the older respondents admit to cross as a pedestrian, when the light is red. This is most often done (by both age groups) when there is only little or no traffic and/or if there is a good overview. Again, the younger more often do it, if they are in a hurry ([9] Bernhoft & Carstensen, 2008: 89). The younger group generally finds it important to move fast and directly in traffic, and they more often argue, that they act, as they do, because they are in a hurry. The older respondents take it easier: they more often than the younger group argue that it is no inconvenience to wait or to stop ([9] Bernhoft & Carstensen, 2008: 92).

The older respondents appreciate pedestrian crossings, signalized intersections and cycle paths significantly more than the younger group. To a larger extent they feel that it is dangerous to cross the road where these facilities are missing. The younger group might appreciate the presence of these facilities, but does not necessarily find it dangerous if they are missing, and does not to the same degree plan their route through town according to their presence ([9] Bernhoft & Carstensen, 2008: 92). So, older people have a stronger need for a safe route.
A significantly higher proportion of the older than the younger group always chooses to walk up to a pedestrian crossing if they can see one, never returns in a non-signalized crossing and never

crosses at a red light. Thus, generally the older pedestrians state a more cautious behaviour ([9] Bernhoft & Carstensen, 2008: 87-8).

There are some differences that relate directly to gender: a significantly higher proportion of women than men in both age groups find it dangerous to walk in a tunnel. A significantly higher proportion of the older women would choose a route with signalized crossings. These differences remain in the regression analysis, where other background variables are taken into account ([9] Bernhoft & Carstensen, 2008: 86-7). Women find a safe route more important than men.

The younger group makes a clear trade-off between safety, lawfulness and mobility, and does what is most practical in the situation depending on the traffic. The older group also makes a trade-off, but safety and lawfulness seem to carry more weight for them. This is important to know, when information and campaigns are being directed towards older road users.
It turns out, though, that some of the older people with poor health conditions may deviate from these principles and – as an example – cross the road irrespective of crossing facilities in order to avoid a detour. So although the older road users generally are more careful than the younger group, it seems that health problems may have the effect that older persons reconsider their behaviour in favour of a more risky one ([9] Bernhoft & Carstensen, 2008: 92-3).

2.4 Operational needs

The 'waiters' at a traffic light were questioned about the reasons why they waited. In the pre-survey 'danger/fear/safety' was cited as a reason for waiting by 45% of sample followed by 'high traffic volume' by 21% and 'I always 'wait' by 20% of sample ([26] Keegan & O'Mahony, 2003: 894). The walkers were asked what their main reason was for not waiting. 32% thought it was safe to cross, 31% of the sample was in a hurry/late/never wait/habit/hate waiting and 20% was impatient ([26] Keegan & O'Mahony, 2003: 897).
Pedestrians were asked to state the main reason based on which they make a decision to cross at a non-designated crosswalk location. The answers to this question were indented to assess users' priorities during their crossing activities. Convenience is the number one priority sited by users (42%) while time-savings were of major importance to 27% of the respondents. Interestingly enough, 30% responded that they do not perceive any major risk crossing the facility at any convenient location since traffic is light enough to allow for safe crossing ([54] Sisiopiku & Akin, 2003: 268-9).
The results indicate that the distance of the crosswalk to the desired destination is a major crossing choice determinant for the vast majority of pedestrians surveyed (90% of total). Therefore, city planners and traffic engineers should place the crosswalks as close as possible to major pedestrian paths ([54] Sisiopiku & Akin, 2003: 269).
Grand River users appreciated the midblock crosswalks and 83% of the survey respondents said that the presence of a midblock crosswalk affected their decision to cross at a specific location. The same is true with the presence of a pedestrian traffic light for 74% of the survey respondents ([54] Sisiopiku & Akin, 2003: 269).
Vegetation and barriers influenced the decision to cross of a significant number of pedestrians surveyed (65%). On the other hand, respondents had mixed opinions about shelters and red brick paving. Only 34% replied that shelters positioned in the median influenced their decision

to cross at the designated location and 41% favoured coloured paving ([54] Sisiopiku & Akin, 2003: 269).

Generally the younger respondents have concentrated their responses on fewer arguments than the older respondents. The overall picture seems to be, that when older persons cross where they are, they more often than the younger persons do it because it is inconvenient/difficult (i.e. because of poor health) to take the detour to a crossing facility and they emphasize a specific reason to cross the road. Contrary to this the younger respondents more often seem to cross the road where they are, because there is no significant reason not to do it – if traffic allows it ([9] Bernhoft & Carstensen, 2008: 89).

The results also show that there can be quite complex interactions between pedestrian safety and comfort. It is not necessarily the case that the two go hand-in-hand. Indeed, increased safety is sometimes obtained at the expense of reduced comfort, and vice versa. This is particularly clear when looking at the relationship between safety and red light violation. Decreased red light violation, and especially a decreased rate of red light violation in conflict with green for vehicle traffic is an indicator of increased safety. But the increased compliance of pedestrians with the traffic signals is likely to be bought at the expense of added delay, certainly at the expense of increased minimum delay for those arriving on red ([12] Carsten et al., 1998: 227-8).

2.5 In general

A survey among 1000 inhabitants on the problems as to be a pedestrian has been carried out in Goteborg, Sweden, in 2000 (Goteborg Traffic Office, 2001). The results showed that the following problem areas were ranked at the highest ones:

- conflicts with cyclists and moped riders
- lack of maintenance and cleaning, e.g. holes, snow cleaning, dog mess
- uneven surface, water puddles
- conflicts with cars, buses and trams
- insecurity.

The experience of the problems is related to the age. Elderly people are more complaining of cyclists and moped riders, and young people of dog mess, water puddles, and cars. Women are avoiding some walking routes where they feel insecurity especially during night ([20] Gunnarsson (ed.), 2001: 16). These problems relate to needs (and the assessment of needs). Elderly people mainly have the need for a pavement without other road users and for young people the most important need is the need for a clean pavement and no cars on the pavement.

Buchanan sites the improvements in order that all respondents are willing to pay the most for: cleanliness, lighting, evenness of pavements, crowdedness, info panels, dropped kerbs at crossings, signs to attractions*, signs to public transport*, benches, raised street at crossings* ([10] Buchanan, 2005: ii, see also below: [22] Heuman et al, 2005).

Heuman et al. (2005) examines how pedestrians value the walking environment and focuses on the evaluation of quality benefits.

The purpose of applying economics to the measurement of pedestrian benefits is to focus the attention of officials, designers and policymakers on the quantum of benefits that accrue to users and where those benefits are generated. Benefits may vary not only by improvement, but by user type, pedestrian environment and by familiarity with the walkway. As a result, we distinguish between 'striders', that is, users who walk with a clear destination and prefer time savings to quality improvements, and 'strollers', that is, users who may not have a clear destination and who prefer quality improvements to time savings. We also distinguish between built-up environments in predominantly urban locations, and green/open environments that are away from high streets. Thus provision such as benches that may be valued highly in green areas may have a negative value in urban areas where they prove to be clutter ([22] Heuman et al., 2005: ii).

Since walking is a public good, there is no fee for the quality of experience that users obtain from making use of the public realm. However, users clearly do value the public realm and were it feasible (or sensible) to charge for it then users would be willing to pay for improvements. Stated preference techniques offer a means to assess that willingness to pay. State preference research can be used to determine the key factors in the choice between competing products or services and measure the relative importance of these factors. It is an established technique for assessing the values of quality improvements ([22] Heuman et al., 2005: 4).
Preferences can varies between locations, different user and non-user groups (pleasure users, shopping users, leisure users, commuters, non-users).
The methodology outlines:

- the selection of user groups;
- the choice of sample sites; and
- the selection of improvements ([22] Heuman et al., 2005: 5).

The way in which pedestrians value improvements is therefore likely to depend on the environment around the walkway. For example, street lighting may be valued very highly among users of inner-city footpaths; however, it may detract from the walking experience on a scenic footpath ([22] Heuman et al., 2005: 5).

Stated preference was used to determine the relative strength of preference between benefits. This involved presenting respondents with pairwise choices between different specifications of improvements. Respondents' choices between these packages provide the data to make the analysed of relative preference.
A contingent valuation exercise asked a series of transfer pricing questions in order to determine how much respondents were willing to accept having only the base levels instead of having the highest levels for all variables together. … To apportion benefits, a final costing question was used to determine what proportions of tax rebates should be apportioned to the variables presented in the stated preference exercise ([22] Heuman et al., 2005: 8).

The willingness to pay for improvements for all respondents (in order of most willing):

- cleanliness
- lighting
- evenness of pavements
- crowdedness
- info panels
- dropped kerbs at crossings
- signs to attractions*
- signs to public transport*

- benches
- raised street at crossings*

* there is reason to believe that this result offers only a partial valuation ([22] Heuman et al., 2005: 9).

The state preference research determined values that suggest significant differences between sample groups. Values vary by context, by journey purpose and whether respondents were users or non-users. Without a doubt, the most important of these differences was variation by environment (built versus open) ([22] Heuman et al., 2005: 9).

Built-up environment	Open environment
Cleanliness	Lighting
Lighting	Cleanliness
Evenness of pavement	Kerbs
Info panels	Info panels
Kerbs	Benches
Signs	Evenness of pavement
Crowding	Signs
Benches	Crowding

([22] Heuman et al., 2005: 10)

There were also some significant differences by journey purpose. These were found to exist for a number of improvements, and the results moved in line with expectations. Nonetheless, the results show that users walking with an element of pleasure in their journey purpose appear to attach a relatively small premium to improvements ([22] Heuman et al., 2005: 10).

2.6 PROMPT

The paper presents some results concerning pedestrian comfort from the PROMPT project. Because the authors think comfort is short-lived emotional reactions rather than cognitive reflections, they interviewed pedestrians on the street asking questions about the actual walking trip and the situation there and then. … For each factor the pedestrians were asked to evaluate the situation there and then on a scale from 1 to 7 with 7 as the best value, as well as stating how important each factor was for them when walking.
Totally the researchers made 1092 interviews at 22 interview sites in 16 European cities in 6 countries (Belgium, Finland, France, Italy, Norway, and Switzerland).

When stating the importance of different factors regarding comfort, the researchers found that in all six countries the feeling of safety and security was regarded as the most important factor for the respondents when being pedestrians. The comfort feeling and the air conditions/air quality were also regarded as factors of high importance in most of the countries. The factor regarded as least important in all countries was the presence of other people.

Most important when walking is to feel safe and secure. On a scale 1-7 European pedestrians feel pretty safe with the mean score 5.5.
Next in pedestrians priority is the air conditions, being second or third on the list of importance in all countries.

Comfort is third on the list of pedestrian priorities, also being second or third on the list of importance in all countries. Most people are satisfied with the pedestrian comfort with a mean score of 5.4.
Fourth on the list of importance is to find the way and get an overview of the area.
Meeting the requirements for rest, food, toilets etc was considered rather important, with a sufficient supply of seating being a little less important. They are somewhat pleased with the possibilities to rest and meet requirements for food and toilets (4.3). But European pedestrians are not pleased with the supply of seating (3.8).
Light conditions were regarded to be of less importance in Norway and Finland, than by respondents in the other countries. Most pedestrians found the light a bit too bright and especially the Italian pedestrians.
The respondents find the traffic somewhat bothersome (4.3), more in France, Italy and Switzerland and less in Belgium, Finland and Norway. Traffic conditions may influence other factors like the air quality, the sound level and feeling of safety.
Surface conditions are quite high up on the list of importance, given high scores in Italy, France and Belgium.
Most pedestrians find the weather comfortable for walking (5.6) and have about the right clothes and shoes for the conditions.
Pedestrians find the sound level somewhat unpleasant (3.9), but tend to find the sounds pleasant.
Most people appreciate their surroundings (5.3) and do not find it important whether the surroundings are open or narrow. The pedestrians state that finding the way easily is important.

The researchers also asked the pedestrians who stated that they could have chosen different routes what were their main reason(s) for the choice on the current trip. The dominating answers were time use (38%) and walking distance (33%), while as many as 15% mentioned the surroundings ([46] Ovstedal & Olaussen Ryeng, 2002).

A factor analysis based on the Norwegian interviews revealed four different pedestrian types:

- For the pedestrian seeking fresh air, space and light, it is important whether the surroundings are open or narrow.
- For the pedestrian seeking security away from traffic the important factors are safety, noise level, comfort and traffic conditions.
- The pedestrian seeking social pleasure stresses the presence of others, the presence of places to sit and to be able to meet requirements, as well as the condition of the street surface.
- For the easy-going pedestrian the weather is important as well as to find her way easily ([46] Ovstedal & Olaussen Ryeng, 2002).

Summarising

General statements on the relative importance of needs can hardly be made. Categories of pedestrians value needs differently, whereas some more general needs likely are common. There are differences in what men and women and different age categories find most important. Also the type of pedestrian (for example ‘strider’ versus ‘stroller’) is important. The ‘rating’ also depends on the conditions under which pedestrians walk. around the walkway. ‘Values vary by context, by journey purpose and whether respondents were users or nonusers’.

However, we can make some general remarks. Young pedestrians mostly want to move fastly and directly in traffic. Older pedestrians appreciate crossings and safety more. In their route choice, for example, older pedestrians appreciate the presence of a pavement (convenience and comfort) and street lighting (safety) more than younger pedestrians. However, there is an exception. Older pedestrians with poor health prefer or at least are used to cross the road irrespective of crossing facilities in order to avoid a detour. Therefore, although the older road users generally are more careful than the younger group, it seems that health problems may have the effect that older persons reconsider their behaviour in favour of a shorter distance at the cost of more risk. Women choose safer options than men. They more often choose routes with signalized crossings and do not walk in a tunnel, suggesting that both the need for safe walking and the need for socially secure walking options dominate.

In the studied literature there was no information about the assessment of needs on the existential level. More research is needed. The importance of needs on the existential level depends on lifestyles urban/rural; household; employment; culture and structure of society. Information about the strategic level is scarce as well. Therefore, more research is also needed on this level.

Researchers use different methods to assess the needs. In studies discussed in this chapter researchers have used surveys, stated preference technique with pairwise choices and interviews on the street. Often, research work only refers to 'operational' aspects, not really to the network level.

3 Identification of requirements

Chapter three focuses on the identification of requirements. What is required to satisfy the pedestrians' needs and wants?

3.1 Existential level

For the time being no information.

3.2 Strategical level

The major responsibility of providing physical facilities that encourage pedestrian travel and help protect the pedestrians resides with traffic engineers. Such facilities include roadways, sidewalks, TCDs, medians, etc. Pedestrian friendly and safe environments involve separation of pedestrian and vehicle traffic, control of flow of pedestrians and vehicles, improvement of visibility, proper communication through signs, and assistance of pedestrians with special needs (US DOT, AAA & NSC, 1994) ([54] Sisiopiku & Akin, 2003: 252).
The following environmental and exposure factors are considered: population density, type of pedestrian crossing, traffic control used at the crossing, surrounding land use type, highway facility type, vehicle travel speed, vehicle volume and pedestrian volume ([54] Sisiopiku & Akin, 2003: 251).
Pedestrian crashes are relatively rare at uncontrolled pedestrian crossings (one crash every 43.7 years per site in this study); however, the certainty of injury to the pedestrian and the high likelihood of a severe or fatal injury in a high-speed crash make it critical to provide a pedestrian-friendly transportation network ([66] Zegeer et al., 2004: 39). A pedestrian-friendly transportation network can help making walking a safe option for people.

A tunnel is an example of a route characteristic. More women than men find it dangerous to walk in a tunnel. Younger women appreciate street lighting more than younger men and feels more troubled by parked cars when crossing the road ([9] Bernhoft & Carstensen, 2008: 87). People can make walking safer (or perceived as safer) when they don't build tunnels, if there is enough street lighting and when there are no cars parked alongside the road (especially at designated crossing locations).

Both the older road users and the group aged 40-49 appreciate pedestrian crossings and signalized intersections most. But the most important conditions for the younger group are a fast and direct route ([9] Bernhoft & Carstensen, 2008: 86). Pedestrian crossings and signalized intersections will make a route safer.
Bradshaw (in: [21] Henson, 2000: 28) made a walkability index which include 10 aspects of neighbourhoods. These aspects are: 'density, off-street parking places, number of sitting spots on benches, chances of meeting someone you know while walking, age at which a child is al-

lowed to walk alone, women's perception of safety in the neighbourhood, responsiveness of transit service, the number of neighbourhood places of significance, size and proximity of parkland, and sidewalk characteristics'. It was noted that this addressed the less measurable aspects of the walking environment ([21] Henson, 2000: 28).

People require convenience when choosing to walk. Convenience includes factors which make the act of walking easy and uncomplicated, such as: lowered kerb, ramps for people with walking impediments, sidewalks free of obstacles near the access to the crossing ([49] Penna de Araujo & Gnecco de Camargo Braga, 2008: 542).
Convenience factors also include walking distances, pathway directness, grades, sidewalk ramps, directional signing, directory maps and other features making pedestrian travel easy and uncomplicated ([21] Henson, 2000: 27).

Walking should also be comfortable. The study of Bernhoft & Carstensen (2007) showed the importance of giving older pedestrians an even surface to walk on. When it comes to walking, an uneven surface on the pavement does not to the same degree prevent young people from walking fast, but it can be the cause of falling for older people, who have problems moving or have reduced eyesight ([9] Bernhoft & Carstensen, 2008).

Some interventions focused on pedestrians are suggested by the findings of Langlois et al. (1997). Physicians may help decrease pedestrian problems among their patients by reducing the impact of disability. Visual problems should be corrected and walking aids, when needed, should be properly prescribed. Some older persons may benefit from specific interventions to improve gait. Recent studies have shown that the walking speed of older persons can be increased by targeted exercise programs ([28] Langlois et al., 1997: 396).

Conditions in the Netherlands make it ideal for walking and cycling: the flat terrain, moderate climate, compact cities and Calvinist culture (emphasising austerity and functionality) have led to excellent pedestrian, bike and public transport facilities ([37] Methorst, 2003b: 52).

Based on the findings of this study, and the review of intervention effectiveness by Fylan et al., an intervention to change aspects of the TPB model in order to change intention to cross in risky situations, and result in changes to actual behaviour, should:

- Focus on specific factors for different demographic groups, e.g., affective attitudes for younger men, especially younger male nondrivers, subjective norm for younger groups, or PBC and outcome evaluations for the oldest women.
- Determine the perceived risk of the target situation, in order to additionally inform which beliefs to target for change (e.g. attitudes were shown to be more important in the situation perceived to be less risky).
- Use a pre-intervention stage (e.g. Stead et al., 2005) to identify salient beliefs and norms within the TPB components, e.g., who are the most influential subjective norm referents, what are the key issues affecting ease of refraining from the behaviour (PBC) for the target group, and to determine what the target group see as the most potentially useful formats (e.g., written versus multi-media).
- Incorporate a full TPB baseline survey to ensure that measures of change can be made.
- Use information, as well as attitude change manipulations, e.g., data on comparative risks of accident statistics addresses self-bias and feeling of invulnerability.

- Use models of attitude change to design methods that will actually result in change of the target beliefs. For instance, Fylan et al. (2006) suggest the Elaboration Likelihood Model (Petty and Cacioppo, 1986) involving an instruction phase which includes elaboration, e.g., group discussion, group action plans, peer group support.
- For groups for whom self-efficacy or PBC is a target (e.g. older women), include modelling of the behaviour (vicarious experience) and/or personal mastery aspects.
- Elicit specific implementation intentions specifying what the person intends to do in the specific situation, or to enable avoidance of crossing in the specific situation, providing suggestions of intentions if needed (e.g., do shopping in a different order so that crossing with a better view is less costly in terms of distance walked).
- Finally, a model of how to evaluate the success or failure of the intervention is needed, based on the theoretical issues (have beliefs changed, do they now predict intention in a different way, have intentions changed?) and also on behavioural data. The evaluation should provide a clear basis for detecting key sources of success or failure ([23] Holland & Hill, 2007: 235-6).

3.3 Tactical level

The need for safety requires factors which reduce conflict between pedestrians and vehicles. Examples are: traffic lights, a police presence, the width of the carriageway ([49] Penna de Araujo & Gnecco de Camargo Braga, 2008: 542), road width, vehicle speed, visibility (being able to see vehicles and be seen), lighting conditions, guardrails ([49] Penna de Araujo & Gnecco de Camargo Braga, 2008: 546).
Comfort includes factors which promote well-being and a feeling of comfort in the pedestrian when using the crossing. Examples are: the state of the surfaces of roads and sidewalks (see strategical), cleanliness ([49] Penna de Araujo & Gnecco de Camargo Braga, 2008: 542), waiting time, space available while waiting to cross, number of pedestrians at the crossing, one-way or two-way street, state of the road surface ([49] Penna de Araujo & Gnecco de Camargo Braga, 2008: 546).

There are significant differences between the older and younger people (and between sex) for the conditions of importance for the pedestrians' route choice. For example, a higher proportion of the older pedestrians find the presence of a pavement on their route most important for their route choice, whereas the most important conditions for the younger group are a fast and direct route ([9] Bernhoft & Carstensen, 2008: 86-7).
It seems like that younger pedestrians have a stronger need for a fast route and being quick at your destination than older pedestrians.

Reduced visibility is a major contributor to pedestrian accidents at night (Owens and Sivak 1993). The visibility distance of dark-clad pedestrians is typically less than one-third the stopping distance at normal highway speed (e.g. Johansson and Rumar 1968 in: [33] Luoma et al., 1996: 377).
Visibility aids such as reflective garments enhance the conspicuity of the pedestrians and cyclists, thus attracting the driver's attention to their presence. The efficiency of visibility aids depends on whether they can visually alert the drivers in time to avoid a collision. Many factors affect conspicuity, including object contrast, size, movement, illumination, background 'clutter'

and road condition, also the cognitive process of the driver and his/her responses in detection and recognition. ([27] Kwan & Mapstone, 2004: 305).
The main finding of this study is that retroreflective markings attached to the limbs (i.e. the wrists and- ankles configuration, as well as the major-joints Retroreflectors and night time recognition of pedestrians 381 configuration) lead to significantly longer recognition distances than when the markings are attached to the torso. This was the case whether a pedestrian was approaching the vehicle (156-169 m vs 96 m) or a pedestrian was crossing the road (241-249 m vs 136 m). The results confirmed the main results of Owens et al. (1994), and the results are in agreement with those of Blomberg et al. (1986). Consequently, the main implication of this study is that retroreflective markings on the limbs, in comparison to those on the torso, increase significantly (by about 60-80%) the recognition distance of night time pedestrians ([33] Luoma et al., 1996: 380/381).

Fluorescent colours improved detection and recognition distance, frequency and reaction time in eight trials (Cole and Hughes, 1984; Hughes and Cole, 1986; Hanson and Dickson, 1963; Michon et al., 1969; Turner et al., 1997; Watts, 1984a; Zwahlen and Vel, 1994; Zwahlen and Schnell, 1997) and only failed to increase detection in one trial (Watts, 1980). Among all fluorescent colours, red, orange and yellow improved detection and recognition in seven trials (Hanson and Dickson, 1963; Michon et al., 1969; Turner et al., 1997; Watts, 1984a; Zwahlen and Vel, 1994). For non-fluorescent colours, yellow improved detection and recognition distance and reaction time in six trials (Hanson and Dickson, 1963; Michon et al., 1969; Turner et al., 1997; Watts, 1980). White yielded higher detection frequency when compared with grey and black colours (Cole and Hughes, 1984; Hughes and Cole, 1986). ([27] Kwan & Mapstone, 2004: 306).
Thirteen trials compared the effect of visibility aids and no visibility aids on observers' responses. The use of visibility aids at night shortened reaction time, enhanced detection and recognition (Allen et al., 1970; Blomberg and Hale, 1986; Johansson et al., 1963; [33] Luoma et al., 1996; Luoma and Penttinen, 1998; Matthews and Boothby, 1980; Muttart, 2000; Owens and Antonoff, 1994; Shinar, 1984; Shinar, 1985; Watts, 1984b). In one trial (Muttart, 2000), retroreflective coloured vests yielded a longer recognition time the WMD was 2.5 (95% CI 0.50 to 4.50) seconds. The WMD for recognition time was 2.5 s (95% CI 0.50–4.50). A flashlight held by a pedestrian yielded a greater detection and recognition distance when compared with no light (Blomberg and Hale, 1986), the WMD were 352 (95% CI 301.68 to 402.32) and 64 (95% CI 39.76 to 88.24) metres, respectively. A leg lamp on a cyclist yielded a greater detection and recognition distance when compared with no lamp, the WMD were 140 (95% CI 95.05 to 184.95) and 13 (95% CI −13.43 to 39.43) metres, respectively (Blomberg and Hale, 1986). ([27] Kwan & Mapstone, 2004: 309).
Four trials compared active with passive visibility aids. Lamps and flashing lights yielded a greater detection and recognition distance and shorter reaction time and greater detection and recognition when compared with reflectors (Blomberg and Hale, 1986; Matthews and Boothby, 1980; Watts, 1984b). Recognition was not improved in one trial (Watts, 1984b, trial two).
There were eight trials comparing different retroreflective colours on visibility. Compared with other retroreflective colours, red and yellow improved detection and recognition distance and time (Marsh and Tyrrell, 1998; Muttart, 2000; Sator, 1978; Sayer et al., 1998; Sayer et al., 1999; Zwahlen and Yu, 1991).
There were four trials comparing 'biomotion' with no 'biomotion' markings. Retroreflective 'biomotion' configuration enhanced recognition distances in three trials ([33] Luoma et al.,

1996; Luoma and Penttinen, 1998; Owens and Antonoff, 1994), but not in one trial (Moberly and Langham, 2002). In the latter (Moberly and Langham, 2002), biomotion retroreflectors did not yield a greater detection distance (41m versus 52 m), the WMD was −11.00m (95% CI −74.33 to 52.33). ([27] Kwan & Mapstone, 2004: 310).

System Continuity: absence of obstacles (street vendors/newsstands, etc.) in vicinity, pot-holes/state of upkeep of sidewalk, lowered kerb, traffic lights for pedestrians, central island ([49] Penna de Araujo & Gnecco de Camargo Braga, 2008: 546).

The need for convenience can be met by having crossing facilities on convenient locations. When crossing the street a significantly higher proportion of the older than the younger pedestrians always chooses to walk up to a pedestrian crossing if they can see one. 'However, the majority of both the older and the younger group often or sometimes crosses the street at their present position, irrespective of the nearby presence of a facility for crossing' ([9] Bernhoft & Carstensen, 2008: 87). The reasons most mentioned for this behaviour are having a good overview of the traffic and/or sparse traffic being present. The younger group more often mention the reason 'if I am in a hurry' than the older respondents (57% versus 23%) and the older group more often crosses the road where they are to avoid a detour (38% versus 31%) ([9] Bernhoft & Carstensen, 2008: 87-8).
Older people with poor health conditions cross the road away from a crossing facility just as often as older people in good health condition, but more often than other (younger) people with poor health conditions. They want to avoid a detour. 'Older respondents – and especially those with poor health – also more frequently cross the road where they are for a specific reason like getting to a bus stop or a shop' ([9] Bernhoft & Carstensen, 2008: 88). 'The overall picture seems to be, that when older persons cross where they are, they more often than the younger persons do it because it is inconvenient/difficult (i.e. because of poor health) to take the detour to a crossing facility and they emphasize a specific reason to cross the road' ([9] Bernhoft & Carstensen, 2008: 89).
Younger people more often cross when the light is red. The reason is that there is little or no traffic and/or there is a good overview. Again, the younger more often do it, if they are in a hurry ([9] Bernhoft & Carstensen, 2008: 89).
The distance of the crosswalk to the desired destination is a major crossing choice determinant for the vast majority of pedestrians surveyed in the study by Sisiopiku & Akin (2003). If the crosswalk is too far from the destination people will not use it.

3.4 Operational level

Important requirements for pedestrians safely crossing the road are: signal displays, pedestrian detection, provision of adequate crossing time, the control and/or advisement of conflicting vehicular movement, intersection design issues, education and enforcement ([61] Yauch & Davis, 2001: 34). 'A key element to improving the pedestrian features at an intersection is the development of a pedestrian signal display that provides a clear indication of its meaning' ([61] Yauch & Davis, 2001: 34).

Blind pedestrians require unambiguous signs and information ([8] Bentzen et al., 2004: 20).

The lack of standardization for walk messages or pushbutton information messages results in variations in message content, length and structure from one APS installation to another. Some messages have been found to be ambiguous, possibly leading pedestrians to cross into opposing traffic. Others have been difficult to understand ([8] Bentzen et al., 2004: 21).
In addition to the standardization of message content and structure, other concerns include the following:
It is important that messages are understandable by all users.
Many people who are visually impaired also have age-related upper frequency hearing loss that limits their ability to understand speech messages.
It is possible for listeners to miss or misunderstand parts of speech messages in loud ambient noise situations.
Non-English speakers and nonnative English speakers are likely to have difficulty understanding speech messages.
Speech messages must be carefully recorded in a clear voice with excellent diction and moderate pacing.
Replacement of signals having speech messages necessitates custom recording rather than off-the-shelf substitution of components ([8] Bentzen et al., 2004: 23).

Also other pedestrians need unambiguous signs. MUTCD section 4E.06 requires that: "The information provided by an accessible pedestrian signal shall clearly indicate which pedestrian crossing is served by each device." However, the most commonly used APS in the United States has been found to provide ambiguous information ([5] Ashmead et al., 2004: 26).

Pedestrian push buttons at signalized crosswalks are commonly used to regulate pedestrian crossing demand and to decrease conflicts between pedestrians crossing and vehicles passing through designated crosswalks; hence, to increase safety ([54] Sisiopiku & Akin, 253).
When pedestrians use sidewalks and cross at designated locations, the separation of pedestrians and vehicles increases, and thereby pedestrian–vehicle conflicts are minimized. In this context, researchers have always been desirous of designing pedestrian crossings that are responsive to pedestrian needs and thus improve pedestrian safety and comfort ([54] Sisiopiku & Akin, 2003: 251).

The improperly crossing of a roadway, inattentiveness, and failure to obey traffic signs have been shown to account for 28, 15, and three percent of pedestrian deaths, respectively. Inattentativeness by pedestrians is a factor that is similar to those highlighted in recent research assessing distracted automobile drivers ([11] Bungum et al., 2005: 271). Traffic requires of pedestrians to be attentive.
One of this study's interesting findings was that a small proportion of pedestrians obeyed traffic signals and followed suggested safety guidelines when crossing a busy street. This finding is also important because improperly crossing the street is the principal factor in those pedestrian incidents when only the pedestrian is in the wrong (29%). Pedestrians are required to use the safe crossing possibilities.
Further our data show that only 13.5% of pedestrians looked left and right while crossing the street, and waited on the curb until the light had turned green before stepping into the intersection. Each of these cautionary behaviours is suggested by the CDC and is designed to reduce injuries and fatalities ([11] Bungum et al., 2005: 275). Pedestrians are required to behave cautionary in traffic.

The authorities should maybe make more crossing facilities. Examples are marked or unmarked crosswalks, presence of median ([66] Zegeer et al., 2004: 38-9). Also the speed limit and number of lanes should be low ([66] Zegeer et al., 2004: 38-9).
Engineering judgment should be used to install crosswalks at preferred crossing locations (at a street light as opposed to an unlit crossing point nearby) ([66] Zegeer et al., 2004: 39).

Research from SWOV shows that especially children in the age 5-11 and people older than 75 years are at risk of becoming a victim of a traffic accident. Most of the victims are made within the built-up area (84%), of which 75% on roads where people may drive 50 km/h. On these roads is the car the most important colliding partner. Driving 30 or more km/h leads to a higher risk of a deadly outcome. An important part (41%) of the serious accidents with (older) pedestrians takes place on or near pedestrian crossings ([41] Ministerie van Verkeer en Waterstaat, 2008: 2).This maybe requires reducing the maximum speed in some areas.

The application of detectors to pedestrian signals cannot solve all the problems inherent in signals, nor can it completely eliminate conflicts or accidents. Except in very low flow situations, where signals are not normally suitable, it is not possible to eliminate delays to pedestrians and vehicles. In the last resort, the determination of how much signal time is to be allotted to pedestrians and the weights given to pedestrian safety and delay as opposed to vehicle delay are outcomes of the political process. But detection can help to redress the balance in favour of pedestrians. The very act of having to push a button to obtain recognition of their presence indicates the current second-class status of pedestrians. In addition, detection is a requirement for making signals more intelligent, for such intelligence requires knowledge of current demand. Pedestrian pre-arrival detection, as used here, can be applied to the fine-tuning of signals. Providing pedestrian stages only when they are needed, giving more prompt activation, extending the pedestrian stage so that late arrivals do not have to wait a whole signal cycle, and taking the size of pedestrian demand into consideration. The fact that the comparatively small manipulations of the signals discussed here produced discernible benefits should encourage the general use of these systems. It should also encourage further experimentation with signal timings in order to obtain additional benefits in terms of pedestrian safety and comfort, as well as the development of more extensive applications covering urban corridors or areas ([12] Carsten et al., 1998).

Sidewalks should be wide enough for two crossing pedestrians, even when they are in a wheelchair or they're pushing a baby carriage ([36] Methorst, 2003a: 10).
Different uses and users require different amounts of space. … In addition , sidewalks and paths contain various types of "furniture" such as signposts, parking meters, mail boxed, garbage cans and sometimes café seating. When people pass each other or an object on the path, they require adequate shy distance. Although a sidewalk or path may have a generous nominal width, its functional width may be much smaller due to various types of obstacles within its right-of-way ([63] VTPI, 2008).

There should be no bottlenecks on any section of an entry exit route, right through the eventual destination. A consistent quality of service is required throughout the route ([55] Stanton & Wanless, 1995: 293).

For both groups of pedestrians, almost half of the crashes occurred as pedestrians stepped off the kerb. These generally happened as they walked out from behind parked cars into the path of an oncoming vehicle. While younger pedestrians had slightly more collisions on the far-side than the near-side of the road, older pedestrians were much more likely to have a collision on the far-side than the near-side of the road. They were also more likely to be involved in 'other' types than younger pedestrians. These sorts of crashes included collisions in car-parks, collisions with vehicles turning into lanes or driveways crossing the path, and collisions with vehicles reversing from parking bays ([47] Oxley et al., 1997: 840/841).

The importance of requirements is assessed by Penna de Araujo and Gnecco de Camargo Braga (2008). In the first field study, involving 424 pedestrians, the Performance Measures (PMs) were ranked in order of importance and a weighting was attributed to each one: Safety (weighting of 38), System Continuity (weighting of 32) and Comfort (weighting of 30). From these relative weightings, it was concluded that pedestrians give priority to factors relating to safety, such as road width, vehicle speed, visibility, lighting conditions and the existence of guardrails. In second place was the PM System Continuity, comprising the attributes: presence of obstacles in the vicinity of the crossing, state of upkeep of the sidewalk, lowered kerb, pedestrian signals and the existence of a central island. In third, and last place came the PM Comfort, with the following attributes: waiting time, space available while waiting to cross, number of pedestrians at the crossing, one-way or two-way street, and the state of the road surface. These results indicate those characteristics of pedestrian crossings that deserve to be given priority treatment ([49] Penna de Araujo & Gnecco de Camargo Braga, 2008: 554).

3.5 In general

Methorst (2003c) describes several categories of points which could be improved:
- physical and mental capability
- trip preparation
- perceptual faculties
- diagnosis and prognosis of risky situations
- behavioural intentions
- decision-making routines
- control over impulses
- action skill
- vehicle skill ([38] Methorst, 2003c: 66).

Some are further described below.
- Physical and mental capability

The requirements set for an individual's physical qualities are not the same under all circumstances and for all modes of travel. The present traffic and transport system and subsystems take account in practice of a fictive 'standard person', who has a certain shape, fulfils certain minimum and maximum dimensions, has a certain degree of agility and muscle strength and possesses certain minimum skills, such as being able to see, hear, feel, think, speak, read, communicate non-verbally, walk, hold something, pick something up and so on. … For a trip on foot, the emphasis lies on strength and stamina ([38] Methorst, 2003c: 67).

- Diagnosis and prognosis of risky situations

Elderly people have acquired a great deal of traffic insight and traffic experience during their lives, and therefore manage to estimate reasonably well what others can or cannot do. It is true that impaired visual faculties make it more difficult to estimate travelling speeds, but they compensate for that by building in wider safety margins. Traffic experience also compensates in many cases for their slower information processing. After all, it means that they know what they must look out for in familiar situations and they do not have to estimate consciously all the risks. A problem is that they do not always remember what has changed in the traffic system over the years, especially as regards the rules and the increasingly hectic nature of traffic.

- Behavioural intentions

Behaviour in traffic is influenced by values and norms of the particular road user. The perception of risk plays an important role in this. Most vulnerable groups have a pronounced sense of danger, leading to a defensive, anticipatory attitude. Young people aged 12 – 25 are an exception to this. This is partly due to poor knowledge of the traffic rules and also low awareness of their environment. They feel that nothing much can happen to them. They estimate the chance of being caught out for dangerous traffic behaviour as low. It is therefore reasonable to assume that a high subjective chance of being caught out will influence them to behave more safely. Pedestrians should have knowledge of the applicable traffic rules ([38] Methorst, 2003c: 70, 176).

In *Vulnerable Road Users* (2003c), Methorst describes the following requirements (they are based on nothing more (or less) than ‘best professional judgment’):

Requirements on the social and public context:

Traffic
- Acceptance that pedestrians behave thoughtlessly
- Control speed of traffic
- protected crossings
- ban bicycles on pavements
- consciousness that within residential areas there are people with walking difficulties

Standards
- WALCYNG Quality Scheme is testing instrument for pedestrian provisions
- regulations for vehicle and making and keeping pedestrians domain obstacle-free
- minimum requirements for ease of crossing main roads
- right-of-way for pedestrians in VRIs
- no parking near GOP’s and VOP’s
- Design for All basic principle for all traffic provisions
- strict enforcement of rules regarding VOP’s. Stopping for pedestrians must become normal again.

Social values
- recognise right to safe mobility
- equality of pedestrian – other modalities
- walking is healthy

- requirements for other modes so that the pedestrian can enjoy road use
- attention for and tolerance towards people with walking difficulties
- public support for limited distribution of functions (compact city) (Methorst, 2003: 178)

Requirements on spatial planning:

Traffic situations
- fulfil safety principle of Sustainable Safety
- functionality: sufficiently wide and high roadway, easy to cross, walkable, can be used by pushchair and wheelchair; no height differences on the route
- no obstructions of view near crossing
- adequate provisions during construction work
- no parking on pedestrian domain
- sufficient crossing time for slow Pedestrians

Network
- closed network that gives direct access to buildings and public spaces
- links up with other networks (connected)
- recognisability of routes and orientation points for people unfamiliar there
- rest points for people with reduced stamina
- effective and direct accessibility of facilities that attract the public
- limit height differences in walking routes to an absolute minimum

Spatial Planning
- Proximity of facilities and essential destinations
- high density and mixed functions improve position of pedestrian in public space
- keep cars (moving, parked) out of the public space by offering alternatives (e.g. parking garages)
- integrate mobility policy, housing policy and economic policy, incl. road safety and public safety
- minimum distances between residential locations and essential destinations ([38] Methorst, 2003c: 180)

And the following requirements on the transport system:

Vehicles
- collision-friendly vehicles
- ban on bull bars
- speed restriction within residential areas
- optimum visibility and audibility where speeds over 30 km/h permitted
- easy-entry of cars and public transport (easy exit)

Transport concepts

- preference for collective modes of transport: reduce quantity of traffic
- promote use of bicycle
- easy boarding transport systems
- availability of on-call transport

Mobility needs:

- replace routine needs by internet ([38] Methorst, 2003c: 182)

Summarising

We will not summarise all the possible, detailed requirements but instead describe some broad categories. of Pedestrians require physical facilities that satisfy their needs and wants. Examples are sidewalks or medians. A further to the environment is that the requirement has to be pedestrian friendly and safe. This refers, for example, to pedestrian crossings and street lighting. The environment should also reduce (the risk of) conflicts between pedestrians and vehicles. This reduction can also be achieved by traffic lights, police presence and reducing the vehicle speed.
Other important needs to satisfy are the needs for convenience and comfort. Kerbs can be lowered, sidewalks should be free of obstacles and clean. Pedestrians require an even surface to walk on. Also short waiting time can be mentioned. Signs have to be unambiguous, especially for people with bad sight. As far as pedestrians have the need to move safely they can develop some capabilities. Education and enforcement could be of help.
Lastly, Methorst (2003c) lists some requirements on the social and public context, on spatial planning and on the transport system.

The chapter contains no information about requirements on the existential level. More research on this subject is needed. On the strategic level also sojourn activities like preconditions for children to play should be receive attention.

4 Current level of service

In this chapter the actual state of the system is described. Only a few publications dealing with this subject were found.

4.1 Existential level

For the time being no information.

4.2 Strategic level

Since the 90-s authorities in many countries, like Germany and the Netherlands, tried to cut in the abundance of traffic signs. In the Netherlands the principles were laid down in the Reglement Verkeersregels en Verkeerstekens (RVV = rules for road users) and in the Besluit Administatieve Bepalingen inzake het Wegverkeer (BABW = rules for road authorities) that came into force in 1992: traffic behaviour should preferably be commanded by self explaining road environments and not by traffic signs. Hereby the legislator consciously pursues to make road users accountable for their behaviour ([39] Methorst et al., 2007: 12).

Many European cities have become increasingly pedestrianized, including car-free commercial districts in older downtowns, and woonerf residential streets where vehicles traffic is slowed to walking speeds. In the United Kingdom they are called “Home Zones”. There are now an estimated 6,000 woonerf in the Netherlands (Beatley, 2000 in: [63] VTPI, 2008).

Over the past two decades these countries (The Netherlands and Germany) have undertaken a wide range of measures to improve safety: better facilities for walking and bicycling; urban design sensitive to the needs of non-motorists; traffic calming of residential neighbourhoods; restrictions on motor vehicle use in cities; rigorous traffic education of both motorists and non-motorists; and strict enforcement of traffic regulations protecting pedestrians and bicyclist (Pucher and Dijkstra, 2000 in: [63] VTPI, 2008).

Weiner evaluated an education and enforcement campaign that targeted elderly pedestrians. Britt, Bergman and Moffat evaluated an enforcement campaign directed at motorists that failed to yield to pedestrians. Although crosswalk markings and pedestrian signals are widely used, Hauer reported the safety effect of these devices is unclear ([52] Retting et al., 1996: 28).

In a former study in Denmark, older pedestrians expressed that they – in line with this study – had difficulties in crossing the road when pedestrian facilities were missing, but also in many cases when they were there (Rosenkilde, 2001). Therefore new types of pedestrian crossing facilities were introduced, so as pedestrian islands in the middle of the road and reducing the width of the road. The new facilities were followed up by information leaflets and resulted in pedestrians feeling safer ([9] Bernhoft & Carstensen, 2008). This can be seen as a plea for an integrated approach.

4.3 Tactical level

The Netherlands has started with a proactive approach called 'Duurzaam Veilig' (Sustainable Safety) in 1997. Part of this is the expansion of the number of 30 km/h zones within the built-up area and the implementation of 60 km/h zones outside the built-up area ([57] SWOV, 2007a: 1). Another measure is that mopeds will drive on the roadway ([57] SWOV, 2007a: 2). Building of cycle- and pedestrians paths, roundabouts and parallel roads and safe edges of roads ([58] SWOV, 2007b: 4).

The approach 'Duurzaam Veilig' works for pedestrians: within sojourn areas the controlled speed is common. But there are no research results known.

In Holland are almost all plots reachable on foot (for most of the pedestrians). Almost all streets within the built-up area have sidewalks on both sides of the road. In other countries this is far less common ([6] AVVa).

4.4 Operational level

Facilities in use in the Netherlands include elevated crossings whose function is to focus attentions on the intersection and reduce vehicle speed (speed being on of the main causes of crashes). Elevated crosswalks also enable pedestrians to cross the street without stepping off a curb, making them beneficial for older people. Crossings are made as narrow as possible to minimise cyclists and pedestrians' exposure to traffic, thereby reducing the risk of crashes ([37] Methorst, 2003b: 53).

Pelican crossings are well established in the UK and in general they succeed in allowing pedestrians to cross roads safely without too much disruption to vehicular traffic. Another crossing is the Puffin crossing. The main differences between the Pelican and Puffin are that the Puffin has a variable-length clearance for pedestrians, controlled by on-crossing pedestrian detectors, and that the far-side red/green-man aspects are no longer used ([14] Crabtree, 1997).

Safety

Many attempts to improve pedestrian safety have involved engineering strategies or the redesign of the traffic environment. Specific strategies utilized include increasing the visibility of pedestrians, attenuating traffic and increasing the number of warning signals for motorized vehicles. Examples are tunnels under, walking bridges over busy streets and erecting more traffic lights ([11] Bungum, 2005).

Safety is considered to be the prime factor in the evaluation and design of pedestrian crossings. Central reservations, pedestrian refuges, guardrails, markings on the road surface and sidewalks and clear visibility for pedestrians and drivers in the area of the crossing, also help to improve the performance of a pedestrian crossing at traffic lights ([49] Penna de Araujo & Gnecco de Camargo Braga, 2008: 540).

Marked crosswalks ([66] Zegeer et al., 2004: 34). In most cases, marked crosswalks are used best in combination with other treatments, such as curb extensions, raised crossing islands, traffic signals, roadway narrowing, enhanced overhead lighting and traffic calming measures ([66] Zegeer et al., 2004: 39).

A number of countermeasures focusing on safer pedestrian participation in traffic have been implemented during the last decades, comprising special measures (such as information campaigns and school education) and equipment (such as clothing) for pedestrians; special road infrastructure (arrangements of roadway layout and pedestrian crossings and over-/ underpasses, signing, street lighting, etc.); vehicle design (car front design, etc.) and special measures for driver behaviour (zone-30, etc.) ([60] Yannis, 2007: 40).
Many studies have shown that retroreflective markings increase the visibility distance of pedestrians at night (e.g. Rumar 1976). Sufficient reflectivity, contrast, area, and durability of retroreflective markings have been considered the key variables affecting pedestrian visibility ([33] Luoma et al., 1996: 377).
Visibility: flashlights, retroreflective markings/bands on the head, waist, wrists, and ankles, jogging vest, dangle tags ([33] Luoma et al., 1996: 77).
Visibility aids such as reflective garments enhance the conspicuity of the pedestrians and cyclists, thus attracting the driver's attention to their presence ([27] Kwan & Mapstone, 2004: 305).
Fluorescent colours, flashlight, leg lamp, retroreflective colours ([27] Kwan & Mapstone, 2004: 306).

During the baseline condition, the percentage of conflicts averaged 2.7 percent at both sites. Introduction of the LED signal head without the EYES display at the Fort Harrison site was not associated with a decline in conflicts. Introduction of the EYES display just prior to the start of the WALK indication reduced conflicts to 0.6 percent at the Fort Harrison site and to 0.4 percent at the Garden site. Incidence of conflicts remained low after introduction of the concurrent EYES display and WALK indication and the repeated EYES display during the WALK interval and during six-month follow-up observations ([24] Van Houten et al., 1999: 32).
During the baseline condition, the percentage of conflicts averaged 2.7 percent at the Fort Harrison site and 2.3 percent at the Garden site. Introduction of the LED signal head without the EYES display was not associated with a decline in conflicts. Introduction of the EYES display just prior to the start of the WALK indication was not associated with a change in the percentage of conflicts at the Fort Harrison site but was associated with no conflicts at the Garden site. Introduction of the concurrent EYES display and WALK indication produced little change at either site. However, the repeating EYES display during the WALK indication further reduced conflicts to 0.6 percent at the Fort Harrison site, while no conflicts were observed at the Garden site. During the follow-up period six-months later, no conflicts were observed at either site ([24] Van Houten et al., 1999: 34).
Traffic signs prohibiting Right Turn On Red (RTOR) during specified hours were very effective at increasing driver compliance with stop lines, reducing the number of drivers turning right on red without stopping and reducing the number of pedestrians yielding the right of way to turning vehicles. Signs giving drivers discretion to turn right on red based on whether pedestrians are present were not very effective. Restrictions on RTOR during the daytime period generally would coincide with hours when most pedestrian crashes occur. Stutts et al. reported that nearly 80 percent of intersection crashes involving pedestrians and turning vehicles occurred between

6 a.m. and 6 p.m., and 95 percent occurred between 6 a.m. and 10 p.m. RTOR restrictions and other countermeasures can help prevent more than 27,000 pedestrian crashes that occur at intersections each year in the United States ([53] Retting, 2002: 35).

The third example refers to the provision of traffic signals at a pedestrian crossing. It is assumed that daily traffic volume is 15 000 motor vehicles and 2000 pedestrians crossing the road. Providing traffic signals is assumed to impose a mean delay of 4 s per pedestrian and 2 s per motor vehicle (Hunt, 1990). The number of accidents is assumed to decline by 12% for pedestrian accidents and 2% for motor vehicle accidents (Elvik et al., 1997). According to a study by Schioldborg (1979), pedestrians believe that traffic signals reduce the number of accidents by 80%. In the present context, this is interpreted as the percentage reduction in the costs of insecurity that pedestrians experience when traffic signals are provided ([16] Elvik, 2000: 43-4).

Crossing traffic arterials at important crossings is mostly dealt with. Crossing a lane from a traffic arterial is mostly not well arranged.
In many cases pedestrians are offered the opportunity to cross the road without dealing with a difference in height. However, this is not a consistent policy, so in pedestrians routes there are some obstacles.
Research from the ANWB and the Voetgangersvereniging showed that the maintenance of pedestrian facilities leaves much to be desired. In shopping areas however pedestrians are pampered ([6] AVVa).

Skills/abilities
A LED signal with or without EYES display, with or without WALK indication can be introduced ([24] Van Houten et al., 1999: 32). Pedestrians will be more focused on looking out for vehicles.
Also painted or sign prompts can be introduced so pedestrians will look for (turning) vehicles ([52] Retting et al., 1996: 34).

Unambiguous signs
In the most commonly used signal, a repeating "cuckoo" is used for crossings that run in a north-south direction and a repeating "chirp" is used for crossings that run in an east-west direction ([8] Bentzen et al., 2004: 20; [5] Ashmead et al, 2004: 26). At least in the United States.

Drunk pedestrians
While modifications to traffic signal operation reduce the risk of crashes involving pedestrians and bicyclists ([53] Retting et al., 2002), the present study evaluated the effects of a new traffic signal phasing on safety for alcohol-affected pedestrians ([31] Lenné et al., 2007: 752). The new traffic signal phasing is the so-called DOR phasing. The ‘Dwell-on-Red’ treatment involves displaying a red traffic signal to all vehicle directions during periods when no vehicular traffic is detected, so that drivers approach high-risk intersections at a lower speed than if a green signal were displayed.

Summarising

Information about the current level of service can hardly be found in literature. It may be assumed that there are substantial differences in the current level of service.
The expansion in number of 30 km/h zones within the built-up area in European cities is an expression of the higher relevancy of the pedestrian in traffic and designing. Many European cities have become increasingly pedestrianised which makes some areas highly pedestrian-friendly whereas motor vehicles dominate in other areas. A typical mix-form is the so-called 'woonerf'. In the Netherlands there are about 6000 of these. Given the diversity of pedestrians context quality, pedestrians have to customise themselves to very divergent types of environment and have to behave accordingly. These environments diverge in pedestrian quality both at the area level (pedestrianised or not) and at the lower level of micro design and lay-out.

No information was found on the existential level. On the other levels the amount of information is limited. Therefore, more research is needed.

5 Assessment of compliance and satisfaction

In this chapter it will be determined to what extent the current and expected future levels of service satisfy the identified needs.

5.1 Existential level

Age and sex

A separate analysis of pedestrian crashes found that for virtually every situation studied, pedestrians aged 65 and older were over-represented in pedestrian crashes compared to their relative crossing volumes ([66] Zegeer et al., 2004: 38).

The occurrence of pedestrian casualties is highest for ages older than 55 and younger than 12 in all European countries. The majority of pedestrian accidents take place inside urban areas; pedestrian accident severity is higher outside urban areas. The percentage of pedestrians killed out of the total number of fatalities varies considerably among the European countries (between 10% in the Netherlands and 27% in the United Kingdom) ([60] Yannis, 2007: 40).

International road accident statistics clearly show that young child pedestrians are at high risk of death or injury. British data reveal that children aged 5–7 years are most at risk (Howarth et al., 1974, cited in Malek et al., 1990), while in New Zealand (Roberts, 1994), the United States (Malek et al., 1990) and Canada (Jonah and Engel, 1983) child pedestrian accidents peak between the ages of 5 and 9 years, coinciding with the early elementary school years. Most pedestrian accidents in New Zealand occur between 8.00 and 9.00 AM and between 3.00 and 4.00 PM (Land Transport Safety Authority, 1992), which coincide with the times at which children walk to and from school. The pattern of school-age children's pedestrian casualties also follows that of the school year, with rates falling during periods of school closure for vacations (Jones and Nguyen, 1988). Casualty patterns are such that injury and fatality rates for boys typically are significantly higher than those for girls, and injuries suffered were found to be most severe between the ages of 5 and 9 years (Jones and Nguyen, 1988). Vehicle speed contributes significantly to the severity of child pedestrians' injuries, particularly at speeds above 50 kph (Pitt, R., Guyer, B., Hsieh, C. C. and Malek, M., 1990 in: [13] Connelly et al., 1998: 443).

Within adults, the risk of being involved in a pedestrian accident varies with age and gender, with older adults at greatest risk of being seriously injured or killed per distance walked (DfT, 2004b) and men at all ages being at greater risk of serious injury than women (DfT, 2004a).

Giving the lowest risk group (those aged 25–59 for each gender group) a baseline index of 1, it can be illustrated that gender interacts with age, based on accident statistics (DfT, 2004a). For men, the 16–24 years group is at the most risk (risk index of 2.13), more than twice the risk of the 25–75 years group, after which the risk index rises again (to 1.73). For women, the over 75s are at the greatest risk (risk index of 3.23, with risk index for young women aged 17–25 being 2.35). The increase for women is greater and occurs earlier than that for men, with an increase of 21% between 25–59 years and 60–74 years (no corresponding increase for men) ([23] Holland & Hill, 2007: 224).

Older road users are over-involved in serious injury and fatal crashes (Mackay, 1988; Federal Office of Road Safety, 1986; Safety for Seniors Working Group, 1989; Evans, 1991). This may reflect the frailty of older people (their ability to withstand crash forces) and ability to recover as well as the severity of the crash itself. Older pedestrian deaths and casualties account for a sizeable percentage of these crashes and this rate is expected to increase in the coming 10 years as the number of older pedestrians increases as a result of an ageing population. Furthermore, due to greater fragility older pedestrians are more susceptible to severe injury than their younger counterparts and face a greater risk of death when involved in a crash (Alexander et al., 1990; Sheppard and Pattinson, 1986 in: [47] Oxley et al., 1997: 839).
A recent study undertaken at the Monash University Accident Research Centre revealed that in 1991, pedestrians accounted for 19% of all road fatalities and ca 30% of these pedestrian deaths were people aged over 65 years (Fildes et al., 1994). This study also revealed that for all casualty crashes and all injury severity levels there is a consistent increase in the rate of casualties per head of population with ages > 44 years. Most noticeably, pedestrian casualty rates increased sharply for pedestrians aged 75 years and over, particularly those involving a fatal or serious injury outcome ([47] Oxley et al., 1997: 839).
This indicates further that it is the slower old walkers, rather than the faster older walkers, who are at greater risk of being involved in a crash ([47] Oxley et al., 1997: 843).

Communities that improve nonmotorized travel conditions often experience significant increases in nonmotorized travel and related reductions in vehicle travel (PBQD, 2000). One study found that residents in a pedestrian friendly community walked, bicycled, or rode transit for 49% of work trips and 15% of their non-work trips, 18- and 11-percentage points more than residents of a comparable automobile oriented community (Cervero and Radisch, 1995). Another study found that walking (in Canada) is three times more common in a community with pedestrian friendly streets than in otherwise comparable communities that are less conducive to foot travel (Moudon et al., 1996 in: [63] VTPI, 2008).

Some TDM studies conclude that walking improvements have little impact on overall vehicle travel (Comsis, 1993; Apoge, 1994) because they only consider commute trips than can shift directly to nonmotorized modes, with no changes in destinations or land use, and no recognition that walkability improvements are important for increasing transit and rideshare travel. Potential travel impacts are much greater if pedestrian improvements are part of smart growth development practices that increase accessibility, for example, by locating schools and shops within residential neighbourhoods. Walkability improvements around worksites can increase transit and rideshare use, because without these employees may feel the need to have a car to run errands during breaks ([63] VTPI, 2008).

5.2 Strategic level

For the time being no information.

5.3 Tactical level

Crossing facilities (on convenient locations)

From 1974 to 2001 nearly 175,000 American pedestrians were killed in mishaps that involved motor vehicles. This type of injury accounts for about 12% of all traffic related fatalities. Such events are frequent, as on average, one American pedestrian is killed every 108 minutes. In recent years this rate translates into just less than 5000 deaths. Another important pedestrian issue is injuries, which are much more frequent events than are fatalities and have numbered approximately 70,000 in recent years. These account for two thirds of all severe traffic injuries in the population ([11] Bungum et al., 2005).
Grand River users appreciated the midblock crosswalks and 83% of the survey respondents said that the presence of a midblock crosswalk affected their decision to cross at a specific location. The same is true with the presence of a pedestrian traffic light for 74% of the survey respondents ([54] Sisiopiku & Akin, 2003).
Vegetation and barriers influenced the decision to cross of a significant number of pedestrians surveyed (65%). On the other hand, respondents had mixed opinions about shelters and red brick paving. Only 34% replied that shelters positioned in the median influenced their decision to cross at the designated location and 41% favoured coloured paving ([54] Sisiopiku & Akin, 2003).

Safety
Ward et al. (1994), in a survey of pedestrian behaviour and accident risk, reported that the majority of pedestrian accidents occurred away from road crossing facilities. In contrast, relatively few accidents occurred at road crossing facilities, although traffic signals with a pedestrian phase and pelican crossings were found to have the most pedestrian accidents. These findings suggest that pedestrians increase their accident risk when they decide to cross away from road crossing facilities. These are the very situations in which the pedestrian has to choose where, when and how to cross the road. When a relatively unsafe choice is made, the pedestrian increases his/her accident risk ([17] Evans & Norman, 1998: 481).

Non-optimal road-crossing behaviour may then, in part, explain the high rate of fatal and serious injury crashes found for older pedestrians (Australian Transport Safety Bureau, 2002; Commission of the European communities (CEC), 2000; Mitchell, 2000; National Highway Traffic Safety Administration (NHTSA), 2001; Organisation for Economic Co-operation and Development (OECD), 2001). ([48] Oxley et al., 2005: 962).

Participants were asked about their use of retro-reflective wear to increase their visibility to drivers at night. Some participants reported using it for themselves and their children while others did not use it at all. However, all of the participants agreed that retro-reflective wear is effective ([51] Redmon, 2003: 28).

5.4 Operational level

Jacobs, Sayer, and Downing (1981) compared road user behaviour at traffic signals, uncontrolled pedestrian crossings and priority junctions in a number of cities in developing countries with similar observations in Great Britain. The comparison indicated that fewer pedestrians chose to use the crossings in Third World cities and, on average, they took longer to cross, partly because they were delayed while crossing whereas such delays rarely occurred in Great Britain. Based on these observations it can be said that no two pedestrians at different settings display comparable behaviour. Therefore, the phenomenon of pedestrian behaviour at crosswalks and crossing compliance with crosswalk location and/or signal setting needs to be investigated with conditions of the environment in which pedestrians are observed as well as with considering pedestrians own characteristics such as age, sex, and socioeconomic situation ([54] Sisiopiku & Akin, 2003).

Preliminary results of a research ([3] Ahuja et al., 2008b) that looks at how people respond to different types of signalised pedestrian crossings, such as pelican, puffin and toucan, which take varying degree of pedestrian priority into account, indicate that pedestrians are more compliant at traffic signals if they are accompanied by children or if their mobility is impaired or if they have heavy luggage. In most of the other cases pedestrians tend to seek gaps at traffic lights and will ignore traffic signal status ([3] Ahuja et al., 2008b).

Convenience

Pedestrians are supposed to register their demand manually by activating the push-button when they wish to cross a street in a conflict-free phase; however, they frequently do not do so ([12] Carsten et al., 1998). Davies (1992) observed pedestrian compliance with the pushbutton installed at signalized crosswalks in the UK and presented the results of his observations that more than half of the pedestrians did not activate the push button to cross. The compliance with the device was 49% in a small town, while in London the rate was 27%. In another location in Toulouse, push button compliance was as low as 18% (Levelt, 1992 in: [54] Sisiopiku & Akin, 2003).

The traditional pedestrian detector, the push button, leaves much to be desired. It requires a positive action by a pedestrian to activate. With the misunderstanding of pedestrian signal operation, many pedestrians do not bother pushing the button. And, at some intersections, intersection designers have placed the buttons in the most convenient to construct and least convenient to find locations ([61] Yauch & Davis, 2001: 34).

Safety

The vulnerability of pedestrians has been highlighted by research on the relationship between vehicle travel speeds and pedestrian injury. Leaf and Preusser (1999) showed that higher vehicle speeds are strongly associated with both a greater likelihood of pedestrians being involved in a crash and with more serious pedestrian injury. Their study indicates that 5% of pedestrians will die when struck by a vehicle travelling at 20 miles an hour or less. This compares with fatality rates of 40%, 80% and nearly 100% for striking speeds of 30, 40 and 50 mph respectively ([26] Keegan & O’Mahony, 2003).

Most pedestrian fatalities in 2000 occurred in urban areas (71%) and at non-intersection locations (78%) (NHTSA, 2000 in: [54] Sisiopiku & Akin, 2003).

Retting, Nitzburg, Farmer, and Knoblauch (2002) examined the practice of ‘‘right-turn-on-red (RTOR)’’. Although the practice of RTOR has many benefits such as reduced emissions and/or traffic delays, the RTOR is likely to increase the risk of crashes and injuries, especially in urban areas where high pedestrian activities occur. Following the adoption of the national RTOR policy in the US, significant increases in pedestrian and bicycle crashes were reported at signalized intersections. This is due to the fact that many drivers do not come to a full stop before turning right on red. Another negative impact of the RTOR is that drivers tend to fail to stop at/behind the marked stop line due to their habits for turning right on red, thereby blocking the pedestrian crosswalk while waiting to turn. This can impede movement and cause pedestrians to walk outside of designated crosswalks. Relatively little is known about the operational and safety effects of prohibiting the RTOR when pedestrians are present as compared with the unconditional RTOR restrictions or restrictions confined to specified hours ([54] Sisiopiku & Akin, 2003).

Howarth, Routledge, and Repetto-Wright (1974) analyzed road accidents involving children when crossing different types of road. The analysis of measures of exposure obtained from interviews with children and from traffic counts on the roads children crossed showed that raw accident figures greatly underestimated the relative risk to children between the age of 5 and 7, that the greater number of accident to boys of this age is not due to their exposure to traffic, and that by the age of 8, boys are not more at risk than girls, even though boys have greater exposure to traffic ([54] Sisiopiku & Akin, 2003).

Pedestrians are generally advised to cross at intersections. Although busy intersections are often equipped with traffic signals and crosswalk markings intended to protect pedestrians from collisions, a substantial number of collisions do occur. About 39 percent of nonfatal pedestrian injuries and 18 percent of fatalities occur at intersections. The proportion of pedestrian injuries that occur at intersections is especially high in urban areas ([52] Retting et al., 1996: 28).
Habib documented an overrepresentation of left-turning vehicles in pedestrian crashes, finding that on an exposure basis, left-turn manoeuvres were about four times as hazardous as through movements ([52] Retting et al., 1996: 28).
However, RTOR increases the risk of motor-vehicle crashes and injuries, especially in urban areas. Following adoption of the national RTOR policy, significant increases in pedestrian and bicycle crashes at signalized intersections were reported ([53] Retting, 2002: 32).

The greatest difference in pedestrian crash types between marked and unmarked crosswalks involved "multiple threats" crashes. A multiple threat crash involves a driver stopping in one lane of a multi-lane road to permit a pedestrian to cross; an oncoming vehicle (in the same direction) strikes the pedestrian who is crossing in front of the stopped vehicle. This crash type occurs when both the pedestrian and the driver fail to see each other in time to avoid the collision.
A total of 17.6 percent (33 out of 188) of the pedestrian crashes in marked crosswalks were classified as multiple threat crashes. None of the 41 pedestrian crashes in unmarked crosswalks was a multiple threat crash. This finding may be due partly to the tendency for drivers to be more likely to stop and yield to a pedestrian in a marked crosswalk compared to an unmarked crossing. At least one motorist must stop for a pedestrian to set up a multiple threat pedestrian collision. ([66] Zegeer et al., 2004: 38-9).

As pedestrians often compete with bicycles for the same space, the subjects were also asked to provide their input regarding safety issues that may result from this type of interaction. Fifty-nine percent of the users were not concerned with the interaction between pedestrians and bicycles and did not perceive bicycles as a safety risk factor to pedestrians that cross at designated locations ([54] Sisiopiku & Akin, 2003).
(b) Second, both survey and movement data indicated that midblock crosswalks are more effective in accomplishing their design purpose compared to signalized crosswalks. Signalized crosswalks, on the other hand, appear the most efficient facilities for pedestrian channelization. However, a large number of pedestrians who select to cross at signalized crosswalks tend to

disobey the pedestrian signal indication in an effort to decrease their delay ([54] Sisiopiku & Akin, 2003).

One result of the current deficiencies of traffic signals is the relatively large number of pedestrian accidents that occur at them. One recent review of the safety of vulnerable road users at signalized intersections compared accident data for Copenhagen, Oslo, Helsinki, Amsterdam and Stockholm. On average, the probability that there would be a pedestrian injury accident in a given year at a signalized intersection varied between 0.20 and 0.51 (Kronborg and Ekman, 1995 in: [12] Carsten et al., 1998).
Of the older people, 66% used the pedestrian crossing (when it is available) and 34% did not. The corresponding numbers for younger pedestrians were 39% who used the pedestrian crossing and 61% who did not (Source: Danish National Accident Databases 2000-2004; in [9] Bernhoft & Carstensen, 2008: 92). Also the results of the questionnaire showed that a higher proportion of the older pedestrians use the facilities available ([9] Bernhoft & Carstensen, 2008: 92).
The study of Sisiopiku and Akin (2003) doesn't compare different age groups of pedestrians. They find, based upon user survey data ('Where do you typically cross on Grand River Avenue?') that 23% of the respondents typically cross at signalized crosswalks, 31% at unsignalized and midblock crosswalks, and 5% at crosswalks of any type. 41% of the respondents responded that they typically cross at any convenient location. At the study site 71% of the observed pedestrians used the crosswalks.
The survey also asked about the frequency of crossing at non-designated crossing locations ('jaywalk'). Approximately a quarter of the respondents replied that they often or almost always jaywalk ([54] Sisiopiku & Akin, 2003: 267). When asked if the respondents are willing to divert from their path in order to cross at a designated location, 20% would refuse to do so and 42% said that they would sometimes divert from their path in order to use a crosswalk ([54] Sisiopiku & Akin, 2003: 268).
Rouphail (1984) performed a user compliance and preference study on marked midblock crosswalks in downtown Columbus, Ohio. The preference study indicated that users perceived the unsignalized marked midblock crosswalk to be unsafe. However, the same crosswalks were rated highest with respect to crossing convenience. Pedestrian crossing compliance rates at the signalized and unsignalized midblock crosswalks were 85.4%, and 86.4% with pedestrian sign (84.2% without pedestrian sign) ([54] Sisiopiku & Akin, 2003).

The fact that pedestrian crossings and signalized intersections are high priority issues for the older road users has also been shown by other studies (Fildes, Lee, Kenny, & Foddy, 1994; Mesken, 2002; Zegeer, Stutts, Huang, Zhou, & Rodgman, 1994). As pointed out by Zegeer et al. (1994), light signals are especially appreciated in dense traffic because older people find it difficult to perceive when a gap is sufficient for their crossing the street. It also underlines that it is crucial to concentrate on how to implement these facilities in a safe way for older pedestrians. In a former study in Denmark, older pedestrians expressed that they – in line with this study – had difficulties in crossing the road when pedestrian facilities were missing, but also in many cases when they were there (Rosenkilde, 2001). Therefore new types of pedestrian crossing facilities were introduced, so as pedestrian islands in the middle of the road and reducing the width of the road. The new facilities were followed up by information leaflets and resulted in pedestrians feeling safer ([9] Bernhoft & Carstensen, 2008).

Traffic signs prohibiting RTOR during specified hours were very effective at increasing driver compliance with stop lines, reducing the number of drivers turning right on red without stopping and reducing the number of pedestrians yielding the right of way to turning vehicles. Signs giving drivers discretion to turn right on red based on whether pedestrians are present were not very effective. Restrictions on RTOR during the daytime period generally would coincide with hours when most pedestrian crashes occur. Stutts et al.10 reported that nearly 80 percent of intersection crashes involving pedestrians and turning vehicles occurred between 6 a.m. and 6 p.m., and 95 percent occurred between 6 a.m. and 10 p.m. RTOR restrictions and other countermeasures can help prevent more than 27,000 pedestrian crashes that occur at intersections each year in the United States ([53] Retting, 2002: 35).

The third example refers to the provision of traffic signals at a pedestrian crossing. It is assumed that daily traffic volume is 15 000 motor vehicles and 2000 pedestrians crossing the road. Providing traffic signals is assumed to impose a mean delay of 4 s per pedestrian and 2 s per motor vehicle (Hunt, 1990). The number of accidents is assumed to decline by 12% for pedestrian accidents and 2% for motor vehicle accidents (Elvik et al., 1997). According to a study by Schioldborg (1979), pedestrians believe that traffic signals reduce the number of accidents by 80%. In the present context, this is interpreted as the percentage reduction in the costs of insecurity that pedestrians experience when traffic signals are provided ([16] Elvik, 2000: 43-4).

We demonstrated measurable reductions in mean speeds with DOR signal phasing. (The ‘Dwell-on-Red’ treatment involves displaying a red traffic signal to all vehicle directions during periods when no vehicular traffic is detected, so that drivers approach high-risk intersections at a lower speed than if a green signal were displayed) Taking a conservative approach and considering the treatment site only, the mean speed at the stop line decreased from 39 to 28 kph, which represents a 28% reduction. There was a concomitant 52% reduction in the proportion of vehicles travelling faster than 30 kph. If speed at the stop line is considered as the potential impact speed with pedestrians in the crossing, this suggests significant reductions in the risk of fatal and serious injury to pedestrians after activation of the DOR phasing. Additionally, we found that mean speeds measured 30m prior to the intersection decreased from 41.7 to 37.8 kph (a 9% reduction) with a 47% reduction in the proportion of vehicles travelling faster than 40 kph, and a 68% reduction in the proportion travelling over 50 kph. This represents a significant reduction in the proportion of vehicles travelling too fast to brake and stop safely before the intersection ([31] Lenné et al, 2007: 754-5).

All of the measures from the Dutch program ‘Duurzaam Veilig’ (see chapter 4) have led to a decline from about 6 percent in the number of deceased and wounded people (who end up in the hospital) in the period 1997-2002 ([64] Wegman et al., 2006 in: [57] SWOV, 2007a: 2).
An evaluation of the traffic education showed that in more than half of the researched projects there is a (small) effect on the self reported behaviour that is relevant for a safe participation in traffic (Twisk et al., 2007 in: [57] SWOV, 2007a: 3). These projects were probably not all about pedestrians.

‘Most accidents occur when pedestrians are crossing the road or walking along the carriageway. Motor vehicles are the biggest danger, but collision with a bicycle can also kill or injure ([15] Department for Transport, 2000: 57).

Crossing the road is the most risky manoeuvre for pedestrians. Sixty-four percent of pedestrian fatalities died as a result of a crash while crossing the road (AVV Transport Research Centre, figures 1999-2003, in: [64] Wegman & Aarts (ed.), 2006: 156). Passenger cars and heavy good vehicles are the most important collision opponent. Of theses fatalities, 25% were crossing at a zebra or another kind of pedestrian crossing. Of the elderly, 75% of pedestrian fatalities die as a result of a crash whilst crossing the road. Of these, 38% were crossing the road at a pedestrian crossing (probably they are also more inclined to cross the road at a pedestrian crossing) ([64] Wegman & Aarts (ed.), 2006: 156).

Previous studies (Bechtel and MacLeod, 2003) reveal that the installations of Scramble signals (all red traffic and all green for pedestrians to encourage safer movements and diagonal shortest paths') at intersections were able to reduce the frequency of accidents by nearly 50% ([2] Ahuja, 2008a).

Being quickly at destination (reduce delays)

The European Community Drive II project VRU-TOO (Vulnerable Road Users Traffic Observations and Optimization) carried out trials of innovative signalized crosswalks that aimed to improve pedestrian safety and comfort by being more responsive to pedestrian crossing needs. These crossings were installed at sites in three European countries. Although important differences were observed in the impacts at the various sites, there were general gains in safety and comfort of pedestrians. Detectors installed at the crossings offered reduced delays by extending pedestrian interval for late arrivals. Thus, red light violation at a crossing in Porto decreased substantially from 83% to 67% ([54] Sisiopiku & Akin, 2003).

The application of detectors to pedestrian signals. In Leeds, conflict numbers were extremely low at Sites 1 and 3. At Site 1, four conflicts were observed before the implementation and one afterwards. This change is significant at the 0.10 level but not at the 0.05 level (p=0.09, one-tailed). At Site 2, the number of conflicts decreased from 41 before implementation to 34 after implementation. This reduction is not significant (p=0.14, one-tailed). However, there was a significant reduction from 23 to 14 (p=0.03, one-tailed) in the number of conflicts to pedestrians who were in the third (i.e., last) lane of crossing. At Site 3, 10 conflicts were observed before and 10 after the implementation. If the three sites in Leeds are combined, the total number of conflicts observed was 55 before implementation and 45 after implementation. This change is significant at the 0.10 level, but not at the 0.05 level (p=0.08, one-tailed).At Site 2, conflicts were analyzed in relation to pedestrian flow. The conflict to flow ratio decreased from 1:2034 in the before situation to 1:2300 in the after situation, indicating an overall improvement.

In Porto, the number of conflicts in the before study was 133, and the number in the after study was 130, so that the overall number of conflicts did not change significantly. However, the conflict to flow ratio went up at both crossings: from 1:66 before to 1:54 after at Crossing 1, and from 1:138 before to 1:120 after at Crossing 2. For Elefsina, on the arm which was equipped with the pedestrian detectors giving advanced green, there was a reduction from 43 to 21 conflicts, i.e., 51% (p<0.01, one-tailed). On the arm with the green extension, an increase from 39 to 43, i.e., of 10%, was observed. The overall number of conflicts in Elefsina changed significantly between the before and after periods from 82 to 64 (significant at the p<0.05 level, one-tailed). The conflict to flow ratio improved substantially, from 1:136 before to 1:253 after.

Skill/abilities

Because crossing a street is considered to be an easily accomplished motor behaviour, it is tempting to recommend simple and elementary educational efforts that target these behaviours. The disappointing news is that many public education programs have not worked well to reduce motor vehicle injuries to pedestrians. Others argue that there is little evidence that educational interventions can reduce the number of pedestrian crashes, there is evidence that interventions can change behaviours. However one intervention conducted on a Virginia college campus was successful in increasing the proportion of students who properly crossed the street as measured by using a zebra crosswalk with the modest total of $10,000 for the entire project. The results of this study are promising as the intervention improved pedestrian road crossing behaviours and these positive behaviours persisted after the formal intervention period had concluded. Although the authors of this study were correct in taking credit of the intervention success they noted that a recent and well-publicized pedestrian death at this college could have influenced pedestrian behaviours ([11] Bungum et al., 2005).
However, the findings reported in these studies show that, while education improves knowledge as measured by verbal report and/or observed behaviour, very few programmes have produced evidence that the training is either durable or that it has reduced child pedestrian casualty rates. Teaching children safe road crossing appeals as an active form of safety intervention. However, given the findings on its efficacy, it may instead provide parents and children with a false sense of confidence in the young child pedestrian's competence and safety ([13] Connelly et al., 1998: 443).

While in theory consideration of both distance and speed of approaching vehicles is highly pertinent to crossing roads, in practice this does not seem to happen ([48] Oxley et al., 2005: 969) The strategy of only relying on distance works best for adult pedestrians (to 69 years) because they can walk fast enough to avoid vehicles. Pedestrians over 69 can't walk that fast so this strategy leads to more risky crossing decisions for this group ([26] Keegan & O'Mahony, 2003: 891-2).

Retting et al. found that signs and pavement markings reminding pedestrians to look for turning vehicles ([24] Van Houten et al., 1999: 30).

During the baseline condition, the percentage of pedestrians not looking for turning vehicles averaged 32 percent at the Fort Harrison site and 26 percent at the Garden site. Overall, introduction of the LED signal head without the EYES display at the Fort Harrison site produced no change in the percentage of pedestrians not looking for vehicles. When the EYES display was introduced prior to the start of the WALK indication, the mean percentage of pedestrians not looking for turning vehicles decreased to 10 percent at the Fort Harrison site and to 5 percent at the Garden site ([24] Van Houten et al., 1999: 32).
Introduction of the concurrent EYES display and WALK indication further reduced the percentage of pedestrians not looking for turning vehicles to 3 percent at both sites. Repeating the EYES display every 9.5 s produced little change in the percentage of pedestrians not looking for vehicles at the start of the WALK indication. Six months later, the percentage of pedestrians not looking for vehicles still was about 2 percent at both sites ([24] Van Houten et al., 1999: 32).
Results demonstrate the experimental signal decreased the percentage of pedestrians not looking for turning vehicles, and this change in behaviour was associated with a large reduction in motor vehicle-pedestrian conflicts. The finding that changes were sustained over six months suggests these were not merely novelty effects. The increase in pedestrians looking for turning

vehicles and the decrease in motor vehicle-pedestrian conflicts take on particular importance in light of Lord's finding that the type of conflicts recorded in this research are closely related to crashes at signalized intersections. Another benefit of the animated eyes display is that it can serve to prompt pedestrians to look for vehicles clearing on the previous yellow at an intersection with little or no red clearance or a vehicle that illegally entered the intersection during the red phase. This may provide a significant benefit given the prevalence of red-light running ([24] Van Houten et al., 1999: 35).

The introduction of either painted or sign prompts alone increased the percentage of pedestrians looking for turning vehicles. The introduction of a second prompt led to further improvements in the percentage of pedestrians looking for vehicles. Introduction of both prompts together led to a large increase in the percentage of pedestrians looking for vehicles similar in magnitude to that achieved by sign and paint at the other two intersections. Increases in checking for vehicles during the experimental period were generally associated with reductions in conflicts at all sites. It is noteworthy that Lord reported a high correlation between the type of conflict recorded in this research and crashes related to turning vehicles. Although the research was conducted at intersections with traffic signals, these relatively inexpensive signs and markings could be installed at pedestrian crossing locations without signals ([52] Retting et al., 1996: 34).

Stephenson et al. (2005) managed a pilot study in which the Kerbcraft model was applied. The scheme is aimed at 5-7 years old, who are taught in small groups of 2-3, at the roadside, by volunteers. Children are taught 3 skills: how to find a place to cross the road; how to cross safely between parked cars; and how to cross safely at junctions. Each skill is taught to the children over four to six half hours sessions. Early results from the evaluation have shown that, after training is complete, children have received Kerbcraft training are making significantly better decisions about where and how to cross the road than their untrained counterparts ([56] Stephenson et al., 2005).

Unambiguous signs

Results of the pedestrian survey completed at the two experimental crosswalks indicate all respondents identified the EYES display as eyes and that they understood its purpose was to prompt them to look for turning vehicles. Reaction to the signal was very positive, and most respondents indicated they would like to see the EYES display implemented elsewhere ([24] Van Houten et al., 1999: 35).

One of the most frequent complaints received by public agency traffic engineers in the United States is that a pedestrian signal is either malfunctioning or improperly timed. Upon investigation, however, the signals in question are found to be operating as intended ([61] Yauch & Davis, 2001: 32).

The ultimate cause of the complaint is pedestrian confusion about the operation and meaning of the pedestrian signal indications. From a human-factors standpoint, pedestrian signals and their related devices have some major design flaws. One of the five basic requirements for a traffic control device, as defined in the Manual on Uniform Traffic Control Devices (MUTCD), is to "...convey a clear, simple meaning." Traffic engineers have not yet satisfied that requirement.

A 1995 study by John E. Tidwell and Devin P Doyle documented the extent of pedestrian confusion. Almost half of the survey participants incorrectly believed that the Flashing DON'T WALK or upraised palm indication meant that pedestrians should return to the curb if they have

just begun to cross at an intersection. A comparable percentage of respondents incorrectly assumed that the display of a steady WALK symbol or word message indicated they could cross safely without conflicts with traffic that also had the right-of-way ([61] Yauch & Davis, 2001: 32).
A study by the City of Montreal concluded that the pedestrian-- clearance interval in a three-color pedestrian signal is better understood but that three-color signals are not more respected than the standard pedestrian signal.
Many traffic engineering agencies have tried to address the pedestrians' confusion by the use of informational signs located at crosswalk ends, typically adjacent to the pedestrian push buttons. These signs, which provide brief interpretations of the three signal stages, may have assisted in educating the public, but they do not appear to have resolved the problem of pedestrian understanding ([61] Yauch & Davis, 2001: 34).

The study described in "Which Crosswalk? Effects of Accessible Pedestrian Signal Characteristics," by Ashmead, Wall, Bentzen and Barlow, demonstrated that when APSs were mounted at pedestrian signal height and placed close to the curb and near the side of the crosswalk farthest from the centre of the intersection, walk signal information was unambiguous, regardless of whether the audible signal came from both ends of crosswalk simultaneously, alternated from one end of the crosswalk to the other, or came from the far end of the crosswalk only. APSs for all experimental conditions had the same walk signal tone-a rapid tick ([8] Bentzen et al., 2004: 20).
APSs with speech messages may seem user-friendly, especially when evaluated in an indoor setting, away from loud traffic sounds and by people who are native English speakers. However, they will not solve all ambiguity problems that can occur.
Tones have been found to be a better way to provide real time information about walk signal status where signal speakers can be installed in locations that provide unambiguous information. Unambiguous information about which crosswalk has the walk signal can be provided when APSs are located on separate poles for each crosswalk, close to the curb and near the side of the crosswalk farthest from the centre of the intersection ([8] Bentzen et al., 2004: 23).

Pushbutton information messages using speech are an excellent way to provide intersection identification and signalization and geometry information. Street names also may be provided to pedestrians who are visually impaired using Braille and/or raised print. Pushbutton information messages are essential where speech walk messages are used. Unless pedestrians who are visually impaired know the name of the street they wish to cross, speech walk messages still are ambiguous ([8] Bentzen et al., 2004: 23).

Speech walk signal messages also have been suggested for providing unambiguous crosswalk identification. However, speech messages cannot be made understandable in all ambient noise conditions and may be of limited use if a pedestrian is not well oriented or not familiar with the area ([5] Ashmead et al., 2004: 26).

Observers noted that when the EYES display and WALK signal were illuminated sequentially, most pedestrians waited until the onset of the WALK indication to begin crossing, even though the EYES display appeared at the time the WALK indication ordinarily is displayed. As a result, these pedestrians lost 2.5 s of their total walk time when the sequential condition was implemented. This did not have much effect at the three crosswalk legs on the side streets because of their long WALK intervals, but it did reduce the length of the WALK indication from 7 to 4.5 s at the one crosswalk leg on Cleveland Street. It is recommended that onset of the EYES display be concurrent with onset of the WALK indication so that no walk time is lost. Repeating the EYES display every 9.5 s during the WALK interval enhances the benefits for pedestrians who departed later during the WALK interval at both sites and is thus recommended ([24] Van Houten et al., 1999: 35/38).

Enough time to cross

More than a conversation piece, however, San Francisco's countdown signals have been associated with a 52-percent reduction in pedestrian injury collisions at pilot locations ([35] Markowitz et al., 2006: 43).

The Minnesota study found a reduction in pedestrians finishing crossing after conflicting traffic received the green indication and 79 percent of interviewees preferring the countdown to the conventional signal. The Montgomery County study found a reduction in pedestrian/vehicle conflicts ([35] Markowitz et al., 2006: 43).

The most important findings of the preliminary behavioural observations were as follows:

The percentage of pedestrians still in the crosswalk when the signal turned red showed a statistically significant decrease after the installation of countdown signals.

The percentage of pedestrians leaving during the flashing red hand or solid red hand increased slightly (but not to a statistically significant degree).

The percentage of pedestrians running or aborting their crossings showed a statistically significant decrease.

The percentage of observed vehicle/ pedestrian conflicts decreased (but not to a statistically significant degree).

Pedestrians who finished crossing on red dropped from 14 to 9 percent at eight intersections that were observed (during one pre-installation data collection period and two post-installation sets). This decrease is statistically significant (probability less than 1 percent of a difference due to random sample variation, pre-installation N = 591, post-installation N = 916, on a two-tailed Z-test of the difference of proportions). ([35] Markowitz et al., 2006: 45).

In the 2001 data collection effort, interviewees finding pedestrian signals "very helpful" increased substantially with the countdown signals-only 34 percent with conventional signals but 76 percent with countdown signals. About 92 percent of post-installation interviewees explicitly said the countdown signals were "more helpful" than conventional pedestrian signals, primarily because they showed the time remaining to cross ([35] Markowitz et al., 2006: 46).

In summary, the results indicate that the countdown timers resulted in a statistically significant reduction in the number of pedestrians crossing during the red man phase. The percentage starting to cross during the red man falls from 35% to 24% ([26] Keegan & O'Mahony, 2003).

Drunk pedestrians

In the United States, annually, more than one-third of all pedestrians 16 years of age or older killed in traffic crashes nationwide are alcohol-impaired (NHTSA 1991). In Florida, the proportion is even higher with pedestrians who had been drinking accounting for 45% of all pedestrian fatalities (Florida DHSMV 1991). A growing body of literature suggests that alcohol consumption by adult pedestrians may play a contributing role in a sizeable percentage of collisions in which the pedestrian is killed ([40] Miles-Doan, 1996: 23).

In a more recent controlled study of pedestrian casualties, Blomberg et al. (1979) found the relative risk of accident involvement among pedestrians increased at Blood Alcohol Concentra-

tion (BAC) levels greater than or equal to 0.1% and accelerated rapidly at higher BAC levels ([40] Miles-Doan, 1996: 23).
The impaired judgement and slower reaction time of intoxicated pedestrians may make them more likely to be involved in impacts of greater physical force: they may be slower to avoid an oncoming vehicle, more likely to walk into the path of a moving vehicle, and more likely to fall asleep in or near the roadway ([40] Miles-Doan, 1996: 24).

Pedestrians using alcohol are at greater risk of being fatally or seriously injured (e.g., Lee and Abdel-Aty, 2005; Martinez and Porter, 2004; [40] Miles-Doan, 1996; Zajac and Ivan, 2003), and a substantial proportion of pedestrian deaths and serious injuries involve intoxicated pedestrians. Blood alcohol concentration (BAC) levels at or above 0.10% have been reported in 30–40% of pedestrian fatalities and casualties (Clayton and Colgan, 2001; NHTSA, 2003). In 2001, 88% of those pedestrians killed in the US who had been drinking had a BAC over 0.08% (NHTSA, 2003). A review of fatal pedestrian crashes in Australia from 1997–1999 showed 70% of males 18–54 years had a BAC over 0.05%, and about 80% of those who were alcohol affected had BAC over 0.15% (ATSB, 2003) ([31] Lenné et al., 2007: 751).
The late evening and early morning hours account for a substantial proportion of alcohol-involved pedestrian crashes. In the US almost 50% of pedestrian fatalities occur between 6 p.m. and midnight. Around half of these pedestrian fatalities involved alcohol (BAC> 0.01%), and this proportion rose to two-thirds between midnight and 3 a.m. (NHTSA, 2003). Similarly, from 1977–1995 in Ume°a, Sweden, half of the pedestrian deaths between 9 p.m. and 5 a.m. were alcohol positive (Ostr¨om and Eriksson, 2001). Recent Victorian data show that 57% of pedestrian fatalities occurred during high alcohol hours (HAH), defined as 6 p.m. through to 6 am (Transport Accident Commission, 2005). Furthermore, 85% of male alcohol-involved pedestrian fatalities occurred during these times (ATSB, 2003 in: [31] Lenné et al., 2007: 751).
In conclusion, alcohol-affected pedestrians are a group that is at high risk of being involved in pedestrian casualty crashes. A range of treatments and programs have been implemented to increase safety for alcohol-affected pedestrians with limited widespread success. The results reported here demonstrate that the DOR modification to traffic signal operation (the ‘dwell-on-red’ treatment involves displaying a red traffic signal to all vehicle directions during periods when no vehicular traffic is detected, so that drivers approach high-risk intersections at a lower speed than if a green signal were displayed) in a regional setting significantly reduced vehicle speeds within the assumed HAH (high alcohol hours; from 6 p.m. through 6 a.m.) for pedestrians. Such speed reductions are associated with substantial reductions to the potential risk of fatal and serious injury to pedestrians, and a reduction in crash risk ([31] Lenné et al., 2007: 1755).

5.5 In general

In the WALCYNG project the researchers developed the WALCYNG-Quality Scheme (WQS). This questionnaire can be used to see how it is with the quality of the facilities for pedestrians and bicyclists ([6] AVVa).

The researchers from the PROMPT-project ([50]) looked at the respondents’ answers (in interviews about comfort) depending on whether they were interviewed in a city centre, a residential area (in inner city or surrounding the centre) or in a suburban area. The feeling of safety and

security is a bit higher in residential areas, where pedestrians are more confident walking alone when dark, not afraid of who they meet and more confident in getting help. City centres have the lowest score for most security aspects, expect pedestrians are less confident in walking alone in daylight in the suburban areas.
Pedestrians in residential areas find the surroundings more appealing with sufficient presence of nature, but are less satisfied with the sounds, the sound level and traffic conditions. People in suburban areas are quite more pleased with the odours and the air quality, and pedestrians in city centres least pleased. Pedestrians in suburbs seem to be most pleased about lighting for seeing the pavement, but less so for reading signs.
Pedestrians in suburbs find the trip even easier without difficult steps or level differences and feel free to choose speed, but they are not satisfied with any aspects of signing in the area. They seem to feel less protected from weather. People in residential areas are especially dissatisfied with freedom to choose speed, steps and climbs, getting an overview and finding the way.

Pedestrians in residential areas are most pleased and the pedestrians in suburbs are least pleased with seating and meeting requirements for food and toilets, while these aspects are looked upon as most important in city centres.

Feeling of comfort gets higher scores in the suburbs, then residential areas and lowest in city centres. It is looked upon as slightly more important in suburbs and slight less important in residential areas ([46] Ovstedal & Olaussen Ryeng, 2002).

Summarising

Many studies were carried out related to services provided to pedestrians. These studies vary widely in subject, scope and methodology. This high variation degree prevents from making general statements on studies results. Generally, the level of compliance and satisfaction with certain measures and services is country- and situation specific. Results are fragmentary and idiosyncratic, hindering an integrated overview.
Several studies focus on factors influencing accident involvement of pedestrians. It can be observed that most statistics only incorporate accidents of pedestrians with other road users. However, there are far more victims than these double-sided traffic accidents. Information on one-sided accidents – falls in particular – usually is missing.
There is no information on the strategic level and the amount of information on the tactical level is limited. Especially for these levels more research is needed.

6 Identification of compliance and satisfaction mechanisms

The sixth chapter consists of the process to identify what mechanisms apply with regard to compliance and satisfaction.

6.1 Existential level

For the time being no information.

6.2 Strategic level

Policies which are designed to encourage walking may obtain their effect by discouraging the use of other modes such as the car. This may be done by making car parking less convenient or more expensive in urban areas or by introducing restrictions on access by cars to central areas of towns or to residential areas. Such measures, seen as negative or restrictive by car drivers, are usually implemented to encourage shifts to more environmentally friendly modes of travel. Policies which encourage particular modes of travel will often be supported by the provision of specific measures. For example countries which encourage walking are more likely to provide walking facilities than those where walking is viewed as less important. The result of this is that where there are low levels of walking the pedestrians may be sharing the road space with other traffic and be at high risk of accidents. This means that the relationship between distance travelled by pedestrians and accidents will not be a linear one. In countries where the amount of walking is large the major part of walking journeys may be travelled in safer conditions on sidewalks and walking lanes, hence keeping the accident levels down. The direction of cause and effect is not easy to see here. Where there is less walking there is less demand for dedicated facilities but then the perceived risks of walking may reduce the amount of walking and hence the apparent need for facilities!
Another factor in this non-linearity will be that where pedestrians form a significant part of the traffic flow the drivers of other vehicles are more likely to make allowance for their presence (this section was inspired by [59] TRL, 2001: 14).

Street lighting is an aspect of the built environment that is important to most of the pedestrians. Younger pedestrians (especially women) and older men think it is more important than older pedestrians but the younger group and men go out more during dark hours ([9] Bernhoft & Carstensen, 2008: 86-7). Younger pedestrians and older men appreciate street lighting perhaps even more because they feel not safe going out during dark hours. This has maybe also to do with their (perception of) capabilities.

6.3 Tactical level

Safety

The characteristics of traffic are an important reason for pedestrians to cross at non-designated crosswalks. In the study from Sisiopiku and Akin (2003) 30% of the sample said that they do not perceive any major risk crossing the facility at any convenient location since traffic is light enough to allow for safe crossing ([54] Sisiopiku & Akin, 2003: 269). A good overview of the traffic and/or only sparse traffic being present is also the most mentioned reason in the study by Bernhoft & Carstensen (also for crossing when the light is red) (2008). Also Keegan and O'Mahony find that 'the percentage of pedestrians crossing during the red man phase appeared to depend on the motivation of the pedestrians and on the number of opportunities to cross the road ([26] Keegan & O'Mahony, 2003: 891). Thirty-two percent said it was safe to cross when asked what their main reason was for not waiting ([26] Keegan & O'Mahony, 2003: 897).
It seems like that pedestrians are not willing to wait for a red light if they think it is safe to cross. The safety depends on the amount of traffic, good overview and the number of opportunities to cross the road. It has to be mentioned that it is not about the actual amount of traffic, overview and opportunities but about the perception of the pedestrians.

A tunnel is an example of route characteristic. More women than men find it dangerous to walk in a tunnel. Younger women appreciate street lighting more than younger men and feels more troubled by parked cars when crossing the road ([9] Bernhoft & Carstensen, 2008: 87).
Pedestrians are not the only groups on the streets. They have to share the streets (and pavements) with drivers, cyclists, roller skaters etc. These other groups can influence the perception of safety of the pedestrians. Older pedestrians find it dangerous to walk when there are cyclists or roller skaters on the pavement ([9] Bernhoft & Carstensen, 2008: 86). They also find it dangerous to cross a street on foot where there is traffic turning and where there are many cyclists ([9] Bernhoft & Carstensen, 2008: 87). In the younger group a significant higher proportion of men (than women) feel troubled by cyclists and roller skaters on the pavement ([9] Bernhoft & Carstensen, 2008: 87). Older pedestrians find it probably more dangerous to share the pavement with other road users because they don't have the capabilities of younger pedestrians. They aren't that fast and also need more time to decide what to do.

Reduce delays

The second problem causes delays for pedestrians. 'Reduction of such delays would encourage pedestrians to use the facility correctly for increased safety' ([34] Lyons et al., 2001: 347). So when the facilities cause a lot of delay pedestrians will not use them in the right way. Important is to reduce the delays so pedestrians will use the facilities in the correct way and are safer.

Convenience

There are tasks that every pedestrian has to perform but not all pedestrians (are able to) do this. For example, pedestrians have to push a button at an intersection to register their demand manually. A lot of pedestrians do not do this ([12] Carsten et al., 1998: 213). This probably has to do with the fact that some people don't know that they have to push the button to get a green light for crossing, other people just don't bother with it and cross the street when they think it is safe.

Knowing what to expect
In relation to the length of time the waiters were required to wait, they were asked whether the length of time they waited was reasonable or not. Seventeen percent considered it to be too long in the pre-survey and this reduced to 7% in the post-survey (after installation of the countdown timer). Those who thought it was a reasonable time to wait rose from 82% in pre- to 93% in post-survey ([26] Keegan & O'Mahony, 2003: 896-7). So when there is a timer that shows how long pedestrians have to wait, more pedestrians think that it is a reasonable waiting time (even if it is the same waiting time). Without a timer pedestrians overestimate the waiting time. The reduced uncertainty will probably lead to safer crossing behaviour.

6.4 Operational level

Safety
Preston (1989) examined pedestrian behaviour and found that females are more likely to adopt compliant decisions and that the number of gaps in the traffic that occur while the pedestrian is waiting for the green man phase primarily determines pedestrians-crossing behaviour. Pedestrian delay at signalised crossings was incorporated into a pedestrian level-of-service (LOS) system by Kaiser (1994) who found that pedestrian impatience and risk-taking behaviour increases after 20 s of delay. Hummel (1999) found that 53% of pedestrians interviewed stated that high speeds of traffic approaching the crossing impeded pedestrians while crossing. The influence of waiting times at signalised crossings on the number of jaywalkers proved to be smaller than assumed ([26] Keegan & O'Mahony, 2003: 891-2).
Why are women more likely to adopt compliant decisions? Are women in general more compliant with rules and norms? The behaviour is more unsafe after 20s of delays. So the amount of delay is an important reason for pedestrians to act more risky.
'Older respondents seem to be more influenced by the fact that an action is illegal and they more often give this reason for refraining from an act than the younger respondents do' ([9] Bernhoft & Carstensen, 2008: 92). Also females are more likely to adopt compliant decisions ([26] Keegan & O'Mahony, 2003: 891). Are women and older people in general more compliant with rules and norms?
When asked 'what do you think would encourage people to wait for the green man?' only 8 percent thinks that enforcement/fines/cameras will work. Twenty percent thinks there needs to be more frequent crossings, 15% want countdown units and 13% wants to reduce the traffic volume.

There can also be confusion about the laws regarding pedestrians. Redmon (2003) found that no one in the Washington, DC, group had a clear understanding of the laws regarding pedestrians' right of way ([51] Redmon, 2003: 28).
When pedestrians return in the middle of the crossing they do this most often because a car is approaching or because they are afraid that an accident will happen. Older respondents more often react to bicyclist approaching ([9] Bernhoft & Carstensen, 2008: 555). 'Many were concerned about crossing at crosswalks and were worried that 'drivers don't necessarily see you' or that drivers may not be aware of or looking for pedestrians' ([51] Redmon, 2003: 28).

Griffiths et al. (1984) examined delays, both vehicle and pedestrian, at different types of pedestrian crossing. The key findings were a tendency for pedestrians to arrive in groups with group

arrival patterns varying from site to site and for the number of pedestrian arrivals to increase during the green man. The percentage of pedestrians crossing during the red man phase appeared to depend on the motivation of the pedestrians and on the number of opportunities to cross the road ([26] Keegan & O'Mahony, 2003: 896-7).
Both survey and movement data indicated that midblock crosswalks are more effective in accomplishing their design purpose compared to signalized crosswalks. Signalized crosswalks, on the other hand, appear the most efficient facilities for pedestrian channelization. However, a large number of pedestrians who select to cross at signalized crosswalks tend to disobey the pedestrian signal indication in an effort to decrease their delay ([54] Sisiopiku & Akin, 2003).

Vaganay et al. seek for causal explanations for the difference in child pedestrian casualties in France, Great Britain, and Northern Ireland. French children seemed to be exposed to a more dangerous environment however they seemed to be able to cope better in this environment ([62] Vaganay et al., 2003). This suggests the mechanism that risky traffic exposure stimulates children and pedestrians to be alerted to the more complex or dangerous conditions and brings them at a higher capability level.

Enough time to cross

One important issue is to adapt the green light period to the walking speed of older people. Experiments have shown that less than 10% of the older test persons had a walking speed that is considered as a normal walking speed ([28] Langlois et al., 1997; Zegeer et al., 1994) and that this should be taken into consideration when planning for older pedestrians (Zegeer, Stutts, Huang, Zhou, & Rodgman, 1993). This is not only because of physical deficiencies but it is shown that it takes more time for older people to perceive and react upon light signals as well as traffic ([47] Oxley et al., 1997; Risser, 1988; Sparrow, Bradshaw, Lamoureux, & Tirosh, 2002; Staahl, 1986 in: [9] Bernhoft & Carstensen, 2008).
It seems that unsafe behaviour of older pedestrians also has to do with inadequate facilities. Their capabilities don't match with the facilities.

Skills/abilities

Previous research also points at the benefits of giving the older pedestrians a better understanding of the functions of a light signal. For example, this can improve their readiness for finalising their crossing although the light has changed to red (Solvi, 1988). Training older road users in judging vehicle speed is another possibility (Oxley & Fildes, 1995). On the other hand, efforts should also be made to enhance the drivers' perception of slowly crossing older pedestrians. Swedish research points at an expected rise in the rate of yielding towards older pedestrians, if pedestrian crossings are marked and speed humps are located at a longer distance from the marked pedestrian crossing (compared to speed humps close to the crossing) (Leden, Gaarder, & Johansson, 2006 in: [9] Bernhoft & Carstensen, 2008).

Use of an animated searching-eyes signal to elicit looking has a biological and psychological basis that is unique in traffic-control signals. This basis makes it an easy-to-understand and conspicuous signal that could lead to a marked increase in compliance in circumstances where the traffic engineer wishes to evoke pedestrian or motorist observing behaviour ([24] Van Houten et al., 1999: 38). The compliance can be improved if the signals are easy to understand.

It is interesting to note that conflicts were nearly eliminated by the prompting interventions, although improvements in the percentage of pedestrians checking for threats were not as dramatic. One explanation is that the method used to observe looking behaviour may not be sensitive enough. Some persons may check for threats without engaging in obvious observing behaviour. It is also possible that the prompts produced a heightened vigilance or primed the pedestrian to make an observing response when other cues, such as moving objects in peripheral vision, indicated the threat of turning vehicles. This outcome would also lead to a larger reduction in conflicts than expected based on the increase in looking behaviour. It is also possible that signs and markings were effective because people concluded that their presence indicated that these intersections were particularly dangerous ([52] Retting et al., 1996: 34).

For example, it is believed that specific cognitive developmental limitations may impose constraints on what young children can learn and do in traffic environments, which also increases their accident risk (Embry and Malfetti, 1981; Sandels, 1975, cited in Michon, 1981; Shinar, 1978; Vinje, 1981 in: [13] Connelly et al., 1998: 443). Children might have lower compliance rate because their capabilities are different; they might not understand all the signals.
Alternative explanations, such as lack of critical experience or competencies, may be more valid. For example, a young child's view and perception of oncoming traffic may be affected by their height restricting their range of view, resulting in less than optimal surveying of traffic from behind a parked car or when obstructed by utility poles, trees, or buildings. Perception of a vehicle's change in apparent size as it approaches may also be affected by the view provided from a child's height. Visual attention studies report that younger children are more easily distracted by task-irrelevant events, less able to sustain attention, and less efficient at searching their visual field (Akhtar and Enns, 1989; Malek et al., 1990; Shinar, 1978 in: [13] Connelly et al., 1998: 444). Children have different capabilities; they are more easily distracted.

The usual developmental explanations for children's failure to judge gaps safely rely on Piagetian cognitive developmental theory (e.g. Embry and Malfetti, 1981; Siegler and Richards, 1979; Vinje, 1981). This suggests that prior to 8 years of age children are not capable of safe judgements. The present findings challenge this, since the children's judgements clearly parallel those of the adult drivers in the Parsonson et al. (1996) study. In addition, the 8–9-year-old children often made judgements that were more risky than those of their 5–6-year-old counterparts, which contradicts a linear, age-linked maturational or cognitive developmental explanation (Markowitz et al., 1998: 450).
However, detection of an object does not equate to its recognition as a hazard and subsequent evasion. The cognitive process of understanding and correct interpretation of visual information is complex, influenced by expectation, vigilance, attention, judgement and experience which can lead to perception errors in drivers who ‘looked but failed to see’ (Hills, 1980; Gale et al., 1996 in: [27] Kwan & Mapstone, 2004: 310).
Safe crossing decisions may require accurate judgement of a vehicle’s time-to-impact, distance and speed. Not all pedestrians can perform these tasks well. Young children might lack the perceptual and cognitive functioning necessary to make such decisions. However, adults (of all ages) seem to have difficulty in coping with such judgements too. They primarily rely on distance ([13] Connelly et al., 1998: 444). Even when old pedestrians had sufficient time to process the time gap of oncoming vehicles, many of them still made unsafe crossing decisions based on

vehicle distance ([48] Oxley et al., 2005: 968). While in theory consideration of both distance and speed of approaching vehicles is highly pertinent to crossing roads, in practice this does not seem to happen ([48] Oxley et al., 2005: 969) The strategy of only relying on distance works best for adult pedestrians (to 69 years) because they can walk fast enough to avoid vehicles. Pedestrians over 69 can't walk that fast so this strategy leads to more risky crossing decisions for this group.

- Children, elderly and people with a disability have more trouble assessing complex situations.
- The possibilities of other traffic to react to mistakes of pedestrians decline when the speed is increasing and with an increasing intensity of the traffic. On traffic arteries, where speed is high and car drivers don't expect pedestrians, drivers have less attention for pedestrians than in residential areas.
- The pedestrian is not very threatening, it is not very likely that pedestrians can cause severe injuries to others and therefore don't enforce respect from other road users as a possible mechanism for other road users to avoid accidents.
- Traffic on a roundabout is quite unpredictable. A lot of drivers don't signal for direction on time.
- A pedestrian has relatively a lot of time to decide and they can, when they doubt, easier wait than a vehicle driver.
- The amount of time to decide can be barely enough in complex situations (lot of traffic, speeds above 50 km/h, limited view); when the pressure of time is higher, the probability of 'wrong' decisions is higher ([6] AVVa).

Clear signs

Pedestrian non-compliance with signs and signals is a significant factor in pedestrian injury collisions nationally and in San Francisco, partly reflecting the frequent misunderstanding of conventional pedestrian signals. Countdown signals attempt to improve this situation by providing information on how much time is left to cross safely ([35] Markowitz et al., 2006: 43). The mechanism for non-compliance is the misunderstanding of signals.

Being quickly at destination

Psychological studies have investigated customers' evaluation and perception of waiting time (Hui and Tse, 1996; Katz et al., 1991). Antonides et al. (2000) found that information on the expected duration of waiting time reduced the overestimation of waiting time. Katz et al. (1991) found that the provision of information did not appear to affect customer satisfaction in their study which focused on the relationship between waiting time estimates and perceived service quality ([26] Keegan & O'Mahony, 2003: 891).

The comparison between the average expected waiting times estimated by pedestrians in the survey who did not wait and the calculated average waiting times shows that in the absence of a countdown timer, pedestrians who did not wait at the crossing overestimated the length of time they would have had to wait by 87 s (200%) on average. When the countdown units were in place, the people who did not wait overestimated the length of time they would have had to wait by under 26 s (60%), indicating an improvement in accuracy ([26] Keegan & O'Mahony, 2003: 896-7).

At most crossings, vehicle precedence is retained during periods when vehicle flow is sufficiently low for pedestrians to identify gaps in vehicle arrivals in which to cross the road. Current operating strategies impose substantially higher delays on pedestrians who obey signal indications. Reduction of such delays would encourage pedestrians to use the facility correctly for increased safety ([34] Lyons et al., 2001: 347).

Summarising

There is, after studying literature, hardly information on the existential level. Further research is needed.
When there is a policy to discourage car use, there will be a higher chance of getting people walking more. Characteristics of traffic and of the route will decide route choice. Pedestrians dislike delay. A reduction of the delay will lead to a more correct use of facilities.
Crossing the street is determined by the number of gaps or opportunities to cross and by the degree of overview. There are indications that females are more compliant than males. A more dangerous environment can make children more alert. Some misunderstanding about signals may arise. Training of pedestrians can help but also making signals easier to understand may reduce the misunderstandings.

7 Promising interventions

In this chapter promising interventions are described.

7.1 Existential level

For the time being no information.

7.2 Strategic level

An UK pedestrian strategy is planned with its own targets for the increase of walking. One target is to halt the current decline in walking by the year 2003 and to increase the proportion of journeys where walking is the main mode to one third of all journeys by the year 2008. Also it is hoped to increase the average distance walked from 200 to 250 miles per person per year by 2008. The strategy will list actions to be taken at a national and local level to encourage walking, such as ([59] TRL, 2001, section 3.3):
- improving road safety,
- reallocation of road space,
- providing pavements fit to walk on,
- making crossing the road easier and
- increasing personal security.

Structure-level principles include large walkable neighbourhoods with essential destinations being located as close as possible to the home. There should be clear distinctions between traffic lanes. Key locations should be centrally located and accessible by public transport.
Recommendations. Modal:
- promote walking and cycling through traffic calming in neighbourhoods
- provide adequate facilities for walking and cycling along the most important routes (at the very least). Tackle the weakest links: arterial road crossings.

Policy:
- Use a cascade approach. Focus on structure first, not technical “gadget”.
- Take an integral approach: don’t think only about pedestrians but about living and mobility
- Don’t wait until countermeasures become unaffordable ([37] Methorst, 2003b: 53-4).

Skills
Some interventions focused on pedestrians are suggested by our findings. Physicians may help decrease pedestrian problems among their patients by reducing the impact of disability. Visual problems should be corrected and walking aids, when needed, should be properly prescribed. Some older persons may benefit from specific interventions to improve gait. Recent studies have shown that the walking speed of older persons can be increased by targeted exercise programs ([28] Langlois et al., 1997: 396).

Making pedestrians aware of safe pedestrian behaviour, the meaning of pedestrian signs and signals and things they can do to improve their own safety; making drivers aware of pedestrians by getting them to drive safely and yield to pedestrians (especially in urban areas and neighbourhoods) ([51] Redmon, 2003: 26).
Planners can show a placard that explains crossing signals. In addition, better education about state pedestrian laws and the rights of pedestrians would be helpful, as would make pedestrians aware of the need to exercise caution and improve their visibility to drivers at night. One of the focus group participants was doubtful that people would wear retro-reflective materials to increase safety but admitted that it was useful to know how much visibility can be increased with retro-reflective materials ([51] Redmon, 2003: 29).

One countermeasure that can draw more attention to pedestrians is increasing their visibility at night. Engineers should do their part by providing adequate lighting for areas of a roadway where pedestrians can be expected, such as crosswalks. This is particularly true during the winter months, when people typically wear dark clothing and are more apt to walk to and from school and work in the dark. Statistics compiled by the National Highway Traffic Safety Administration indicate that 50 percent of pedestrian fatalities occur between the hours of 6:00 p.m. and 12:00 a.m. (a six-hour window) ([51] Redmon, 2003: 29).
However, as mentioned previously, design is only one part of a three pronged approach. States and localities also should focus pedestrian safety efforts on reaching out to pedestrians and drivers. Countermeasures can go only so far if people engage in activities that put their lives and the lives of others at risk. Convincing people to change their behaviour will have the most lasting effects. However, it is the most difficult thing to do ([51] Redmon, 2003: 29).

‘Apart from the general vulnerability of pedestrians and cyclists, the fragility and decreased balance of elderly people plays an important role in injury causation. The influence of imbalance can be reduced by exercise and training. That does not alter the fact that the independent mobility of elderly people as cyclists or pedestrians will be gradually restricted because of their physical limitations, which warrants some form of motorized support. This support can vary from scoot mobiles or four-wheeled moped engine vehicles, to passenger cars. In order to guarantee safe mobility for as long as possible, it is desirable that vehicles and infrastructure are well adapted to the capabilities and limitations of elderly car drivers (Davidse, 2006; [58] SWOV, 2005b; Hakamies-Blomqvist et al., 2004, in: [64] Wegman & Aarts (ed), 2006: 157).

‘A postponed independent mobility of children can have negative consequences for their future safety. They may be at higher risk as they become secondary school pupils, simple because they have acquired less experience at a younger age (because parents take them to school by car, because large-scale facilities are at the periphery of urban areas) ([64] Wegman & Aarts (ed.), 2006: 157). Measure: let children at a younger age walk more.
Planning new neighbourhoods in small, compact towns close to the town centre, for example, keeps distances to facilities as small as possible ([64] Wegman & Aarts (ed.), 2006: 158).

Safety
Examples of some of these pedestrian improvements are given in Table 3 (see below). In addition to those options, proper planning and land use practices should be applied to benefit pedestrians ([66] Zegeer et al., 2004: 40).

The major responsibility of providing physical facilities that encourage pedestrian travel and help protect the pedestrians resides with traffic engineers. Such facilities include roadways, sidewalks, TCDs, medians, etc. Pedestrian friendly and safe environments involve separation of pedestrian and vehicle traffic, control of flow of pedestrians and vehicles, improvement of visibility, proper communication through signs, and assistance of pedestrians with special needs (US DOT, AAA & NSC, 1994, in: [54] Sisiopiku & Akin, 2003).

- Reduce excessive speeds of motor vehicles on roads likely to be crossed (or shared) by pedestrians to reduce stopping distances and, if a pedestrian accident does happen, to minimize its consequences ([60] Yannis, 2007: 41).
- Improve vehicle design to prevent pedestrian accidents or reduce their severity ([60] Yannis, 2007: 41).

Action 1: Reducing Vehicle Traffic. The aim of this action is to solve conflicting functions of an area in which too much traffic is distracting or dangerous. This applies to areas where living, recreation, schooling, or shopping are dominant functions that do not tolerate too much fast traffic. The measures taken generally should be considered in an area-wide perspective and should be expressed in a traffic management scheme. What measure is most appropriate in each situation depends on the overall environment, its dominant function(s), layout, characteristics of groups using the environment, total space available, available means and support of local users (traffic restrictions/restraint; ring road/bypass; truck ban; cul-de-sac; closure of side streets; one-way street; location of parking at border of protected area) ([60] Yannis, 2007: 42-46).
Action 2: Lowering Vehicle Speeds, Generally (Especially Along Main Roads). The aim of this action is to offer a better chance for road users to avoid a collision and at least to reduce the consequences of an incident. Lowering vehicle speeds offers better conditions for looking out, avoidance actions and communication between different road users. This may result in more equality and a lower aggression level, more efficient use of the road, thereby improving road capacity, and easier planning of other measures, such as crossing measures. Speed limiting measures should be functional in relation to environmental or road characteristics (overall speed limit for urban areas; roundabout; local speed limit sign; feedback device; rumble strips; transverse/lateral marking; "Jiggle bars; "speedlimiter in vehicles; urban boulevard).
Action 3: Area-Wide Speed-Reduction or Traffic Calming Schemes. This action puts together the ideas of the previous two, vehicle traffic reduction and speed reduction. The general aim is to achieve that through traffic has a subordinate function in a certain area. One commonly applied approach is 30-kilometer-perhour zones in residential areas (gate-effect/threshold; narrowed carriageway; advance warning for speed reduction; alignment change; round-top hump/speed cushion, flat-top hump; raised junction; planting/landscaping).
Action 5: Softening Impacts. Because pedestrians are vulnerable, a collision with a solid vehicle can have severe consequences. Sharp and blunt vehicle parts, like mirrors or windscreens, as well as unprotected moving parts (including the overall front part) are hazardous. The aim of softening impacts is to reduce the consequences of a collision. However, it is possible for compensation on the part of the driver (speeding, less attention, etc.) to cancel effects of measures intended to reduce severity of the impact ("friendly" (soft) vehicle fronts; side-protection screen on trucks and other vehicles) ([60] Yannis, 2007: 42-46).

Based on 37 trials, visibility aids have the potential to increase conspicuity and may enable drivers to detect and recognise earlier those pedestrians and cyclists who used these aids. Public acceptability of these strategies would depend on their ease of application, maintenance and cost ([27] Kwan & Mapstone, 2004: 311).

The following strategy can be applied in the design of the urban space with regard to the safety of and environment:
- extend the foot space through implementing area-wide walking routes and more pedestrian-priority areas.
- concentrate the motor transport space to an automobile network for heavy traffic outside residential areas and city centres
- establish traffic calming space foremost in residential areas and central areas by means of physical and other regulatory measures in such a way that pedestrians are not subordinated to automobiles ([20] Gunnarsson (ed.), 2001: 25).

Comfort and convenience

Action 6: Provision of Sidewalks. Sidewalks are reserved for pedestrians. However, they generally combine several purposes. For instance, sidewalks also are used to place bicycles, terraces, pickets, road signs, waste baskets, stops, verge, lighting, information, etc. This often means that net space for pedestrians is limited. Sometimes sidewalks have to be shared with bicyclists; this should not be recommended. Well-designed and well-kept sidewalks are badly needed because many pedestrian accidents happen on sidewalks (proper physical design; protection against unwanted usage).

Action 7: Provision of an Integrated Walking Network. The term "walking network" refers to the design of pedestrian routes across an urban area, linking all types of neighbourhoods and facilities frequented by pedestrians (residential areas, city centres, commercial centres, leisure areas, schools, administrative buildings, etc.). The aim of pedestrian networks is to offer short and direct, but also pleasant, protected, comfortable, safe and secure routes between important destinations. Basic provisions like shelters, stops, benches, waste baskets, crossings, call boxes, letter boxes, special lighting, pedestrian finger posts and maps, etc. must be integrated (pedestrian zone/streets; zebra crossings; push-button signalized crossings; yellow flashing light at crossings; stop-line before pedestrian crossings).

Action 15: Pedestrian-Friendly Walking Surfaces. Bad construction of the infrastructure may cause injuries to pedestrians (bumping, slipping, tripping, spraining, or falling). A pedestrian-friendly walking surface implies evenness, roughness, smooth gradient, obstacle-free space and absence of dirt, pits, holes, snow and ice (differentiated paving/contrasted surfaces; anti-slip surface of walking path (sidewalk or crossing); obstacle removal from sidewalks or footpaths; durable walking surfaces; ice tracks for pedestrians) ([60] Yannis, 2007: 42-46).

By reducing automobile traffic in city areas, the streets will be more attractive and liveable for all citizens ([20] Gunnarsson (ed.), 2001: 22).

Squares, streets and places should be arranged to encourage informal meetings with the provision of seats, cafes etc. The walking environment will be attractive to linger and wander through planting of trees, and arrangement of works of art. Arcades and roofs can give weather protection. Monotonous environments should be avoided, also underpasses which are dark and narrow. Advertisement on pavements should be banned. To avoid disorientation, there should be easily understandable information by signs and maps as to suitable routes and how to reach buildings and activities by foot, and posters on the current positions. Landmarks or other city characteristics are desirable for orientation and guidance ([20] Gunnarsson (ed.), 2001: 26).

A walking route plan should be established and implemented covering the whole urban area with safe and enjoyable connections between homes, schools, workplaces, shops, service centres and recreational areas, and to terminals, stops and parking areas ([20] Gunnarsson (ed.), 2001: 27).

Destination

Action 16: Reducing Walking Distances for the Handicapped. People with walking problems or endurance problems have trouble covering great distances when walking and need provisions nearby. Planning of special provisions aims at contributing to their special needs (provision of reserved parking spaces for the handicapped) ([60] Yannis, 2007: 42-46).

‘Land-use planning and urban renewal should be directed to reduce distances and bring back proximity, e.g. by increasing urban density, development of neighbourhood centres with a variety of residences, workplaces and service centres in local areas. The possibility to get a high level of public transport service is dependent on the co-ordination between land-use planning and the planning and operation of the public transport system’ ([20] Gunnarsson (ed.), 2001: 22).

All near and local destinations should be reachable by a pedestrian network. This network should also be connected to the network of other transport possibilities. This applies to parking places, public transportation stops and bicycle sheds ([36] Methorst, 2003a: 10).

Skills/abilities

Child education programmes are the most common approach to prevention (Malek et al., 1990; Roberts, 1994) and there is wide acceptance of the value and necessity of teaching pedestrian skills (Christoffel et al., 1986; Demetre et al., 1993; Grayson, 1981; Malek et al., 1990; Yeaton and Bailey, 1978; Young and Lee, 1987 in: [13] Connelly et al., 1998: 443).

The Department for Transport in the UK published practical guidance for local authorities on the sort of measures they should consider. These include:

- pedestrianisation schemes for town centres;
- adequate lighting for safety and personal security;
- traffic calming to reduce vehicle speed in key areas.

Local publicity should raise awareness of, for instance, the need to be visible to traffic. We recommend children in particular wear or carry reflective material at night ([15] Department for Transport, 2000: 59).

The Ministry of Transport, Public Works and Water Management does not approach all vulnerable groups separately. A comprehensive approach of measures is more effective. For pedestrians they want to take the following measures:

- improvement of the collide-friendliness of passenger cars by intensifying the test procedures in EuroNCAP en in the EU legislation;
- making crossing situations safer;
- stimulating the voluntarily introduction of pedestrian detection systems in cars ([41] Ministerie van Verkeer en Waterstaat, 2008: 54).

‘Many of these deaths (children killed on the road) could be avoided by improving education, making drivers take more responsibility for the safety of young passengers and pedestrians, and better design of vehicles and roads, according to the new OECD report, Keeping Children Safe in Traffic.
Keeping Children Safe in Traffic recommends countries implement a series of measures to address this issue:

- High quality road safety education to improve children’s skills and awareness of risk, and publicity to encourage use of safety equipment such as seat belts and cycle helmets
- the focus of responsibility for child road safety should be shifted towards drivers. Even children educated and trained in road safety skills are less able than adults to use their knowledge consistently.
- Traffic engineers and urban planners should consider child safety in road design.
- Vehicle designers and manufacturers should giver more attention to protecting pedestrians and cyclists ([44] OECD, 2004).

7.3 Tactical level

Skills
As also pointed out in former research, the older pedestrians would benefit from advice regarding how to compensate for their physical deficiencies and how to choose their routes on their daily walking trips (Sheppard & Pattinson, 1986) ([9] Bernhoft & Carstensen, 2008).
It would also be worthwhile to consider the development of behavioural and training packages aimed at older pedestrians to assist their awareness of declining abilities and adoption of safe road-crossing practices ([48] Oxley et al., 2005: 970).

Safety
Conflicts between pedestrians and vehicles can be reduced through physical separation, but this can be expensive and difficult to implement ([52] Retting et al., 1996: 28)**.**
Improve visibility of pedestrians to drivers (and of vehicles to pedestrians) to avoid masking pedestrians and improve communication between pedestrians and drivers ([60] Yannis, 2007: 41).
These findings have practical implications for road safety countermeasures aimed at improving the safety of older pedestrians. An emphasis on designing safe road environments, such as vehicle speed restrictions, to facilitate older pedestrians’ mobility and safety is clearly warranted ([48] Oxley et al., 2005: 970).

Participants were asked about their use of retro-reflective wear to increase their visibility to drivers at night. Some participants reported using it for themselves and their children while others did not use it at all. However, all of the participants agreed that retro-reflective wear is effective ([51] Redmon, 2003: 28).
Improve road user behaviour through education, enforcement, or social measures considered as indispensable elements of traffic safety policies complementing technical measures ([60] Yannis, 2007: 41).
Many attempts to improve pedestrian safety have involved engineering strategies or the redesign of the traffic environment. Specific strategies utilized include increasing the visibility of pedestrians,6 attenuating traffic7 and increasing the number of warning signals for motorized

vehicles.8,9 There is little question that engineering strategies are appropriate and effective, however, the costs associated with these changes, such as building tunnels under, and walking bridges over, busy streets and erecting more traffic lights can be prohibitive and such steps are not always feasible ([11] Bungum, 2005).
Reduce conflicts between pedestrian flows and motorized traffic, thus reducing exposure, through the segregation of parts of the pedestrian network ([60] Yannis, 2007: 41).

Knowing what to expect
Improve readability of the road environment for all road users to facilitate anticipation of changes in the driving situation and avoid wrong expectations ([60] Yannis, 2007: 41).
The Dutch SWOV has formulated five safety principles. These are:
Functionality of roads; every road has a function.
Homogeneity of masses and/or speeds and direction: equivalence in speed, direction and mass at different speeds.
The forgiving nature of the environment and of the mutual road users.
The recognisability of the design of the road and the predictability of the course of the road and of the behaviour of road users.
That road users have the ability to assess their own task competence ([57] SWOV, 2007a: 2).

Crossing facilities (on convenient locations)
Grand River users appreciated the midblock crosswalks and 83% of the survey respondents said that the presence of a midblock crosswalk affected their decision to cross at a specific location. The same is true with the presence of a pedestrian traffic light for 74% of the survey respondents ([54] Sisiopiku & Akin, 2003).
Vegetation and barriers influenced the decision to cross of a significant number of pedestrians surveyed (65%). On the other hand, respondents had mixed opinions about shelters and red brick paving. Only 34% replied that shelters positioned in the median influenced their decision to cross at the designated location and 41% favoured coloured paving ([54] Sisiopiku & Akin, 2003).

Crossing facilities should be on convenient locations, not for car drivers but for weaker pedestrians ([7] AVVb).

The Department for Transport in the UK published practical guidance for local authorities on the sort of measures they should consider. These include:
- well-planned pedestrian routes, such as footpath networks linking housing to schools, shops and public transport;
- adequate lighting for safety and personal security;
- well-designed and positioned crossings;
- traffic calming to reduce vehicle speed in key areas.

Pedestrians themselves need to take sensible precautions, like crossing the road at pedestrian crossings ([15] Department for Transport, 2000: 59).

7.4 Operational level

In general

The Department for Transport in the UK published practical guidance for local authorities on the sort of measures they should consider. These include:

- adequate lighting for safety and personal security;
- well-designed and positioned crossings;
- improved signal-controlled junctions; and
- ‘Home zones’ have been introduced in several European countries. A ‘home zone’ is where a whole residential area is treated with a combination of traffic calming and other measures to make a safer, quieter neighbourhood ([15] Department for Transport, 2000: 58).

Traffic engineers and urban planners should consider child safety in road design ([44] OECD, 2004).

Universal design, namely designing economically for as many people as possible at once should be the guiding principle.
When tackling problems, land-use should first be addressed, then design criteria should be used, such as locating schools and shops close to home, and then finally design should be addressed on a network level, making roads and paths as effective and as safe as possible. … Poor infrastructure designs cannot be eliminated by good measures taken at the site level. To improve safety, facilities should be only be employed for their intended use ([37] Methorst, 2003b: 53).

Shared Space

Shared Space does not focus on limiting car traffic and its speeds, but on voluntary behavioural change of all road users, supported by appropriate design and layout of public space. Improved traffic behaviour should be achieved by replacing traffic rules, particularly traffic signs and typical traffic engineering elements by informal social rules. Shared Space is characterised by the absence of traffic lights, signs and signposting and a clear and open design of public space. The basic formal traffic rules are still applicable. The aim is common use of the available traffic space within a sojourn area. Especially car drivers should be more aware of the social and cultural structure that one should adapt to ([39] Methorst et al., 2007: 5).
‘Shared space assumes that traffic behaviour is more strongly influenced by the character of a place or area than by all sorts of formal do’s and don’ts. For example, a highly visible school with playing children and a tailored road environment have a much stronger effect on car speeds than speed humps and traffic signs that depict crossing children that are nowhere to be seen.
An important reasoning behind Shared Space is that by taking away traffic regulation elements and by sharing road space, a certain feeling of insecurity is created. This is assumed to lead to a higher attention level and thus to safer road user behaviour ([39] Methorst et al., 2007: 6).

‘In the last decennia, under the influence of a deteriorating environment and road safety, on several occasions Shared Space-like principles have been introduced: the Woonerf idea, sojourn-play areas, Shopping Erfs, traffic calm neighbourhoods, home zones, 30 km/h zones etc (Loiseau, 1990 in: [39] Methorst et al., 2007: 9).
Road sections and streets that have only a limited amount of traffic could be re-equipped and reconstructed to stress their sojourn function. In the meantime, since the 90-s, also regarding traffic arteries there are traffic calming developments. A number of through routes through

villages and smaller towns were reconstructed to improve their residential and shopping function ([39] Methorst et al., 2007: 10).
But there are also some objections to this concept. It is not self-evident that all road users are able to detect and recognise danger and risks (which is assumed) or know what to do to produce the correct, safe response behaviour. There is also an ethical argument: is it good to have the strongest party setting the stage ([39] Methorst et al., 2007: 12)?
When there are relatively many people that are unfamiliar with the situation, complexity is severely elevating risk. The Shared Space design principle of emptiness surely is an asset, but much swarming traffic definitely is not without actual risk ([39] Methorst et al., 2007: 15).

An important question is under which preconditions can Shared Space be implemented? From evaluations and observations in practise one can conclude:

- only in sojourn areas without extraneous traffic (traffic that does not have an origin or destination within the area); it is essential that the road users have some tie with either the areas or its sojourners;
- suited for central areas along old traverses and arteries through villages and small towns, without a inter local function;
- parking must be realised outside the to be renovated areas; terraces, goods displays in the passageway of pedestrians should be effectively suppressed;
- for pedestrians a safe zone should be available, where they are not bothered by ‘free’ bicyclists;
- participation of public space users, residents, commercially interested and all relevant disciplines is crucial for achieving spatial quality and to obliterate the sharp edges of the design philosophy ([39] Methorst et al., 2007: 16).

Enough time to cross

In summary, the results indicate that the countdown timers resulted in a statistically significant reduction in the number of pedestrians crossing during the red man phase. The percentage starting to cross during the red man falls from 35% to 24% (z ¼ 26:07) ([26] Keegan & O’Mahony, 2003).
There is considerable evidence that changing the signal settings at signal-controlled pedestrian crossings can affect safety (e.g., GaÊ rder, 1989). But most previous work has examined the safety of signalized crossings as compared to non-signalized crossings (e.g., Kraay et al., 1974). Studies on signal staging have been much rarer (GaÊ rder, 1989 is an example).
The work reported here studied the effect of signals designed in such a way as to make the timings more responsive to pedestrian needs, i.e., to affect signal timings. The work was carried out as part of the DRIVE II project VRU-TOO (Vulnerable Road User Traffic Observation and Optimization). Advanced pedestrians crossing facilities were installed at sites in three European countries and a comprehensive evaluation of the impacts was carried out, with particular emphasis on changes in pedestrian behaviour and safety ([12] Carsten et al., 1998).
The generic VRU-TOO system is extremely simple in concept. Microwave detectors are mounted on traffic signals to register the approach of pedestrians. This detection can be applied to:
(a) replace the normal push-button on signalized pedestrian crossings;
(b) provide earlier activation of the pedestrian stage;
(c) provide an extension of the pedestrian stage for late arrivals;

(d) provide longer pedestrian stages when there are large numbers of detections ([12] Carsten et al., 1998).
The choice of detection system was based on a review of the alternatives available (Sherborne, 1992). This review covered microwave detectors, infrared detectors and pressure-sensitive mats. The conclusion was that microwave detectors had the advantage over infrared systems of being able to discriminate direction, so that only movements towards a crossing could be registered, and presence or movements away from the crossing could be ignored. Infrared detectors lacked this ability to discriminate by direction. Mats were merely presence detectors. They also required substantial upheaval to the footway if they were installed to cover all pedestrian approaches to a crossing, making them inconvenient and expensive ([12] Carsten et al., 1998).

Passive interventions that create a safer environment are most likely to be effective for preventing injuries.20 Improvements in older pedestrians' safety can best be achieved through combined interventions involving reduced traffic speeds,8 increased use of median strips or traffic islands in roadway design, and increased crossing times ([28] Langlois et al., 1997: 396).
Thus, the recommended walking speed and the corresponding timing of traffic lights in areas with large numbers of older persons should be modified to reflect the range of abilities among older pedestrians ([28] Langlois et al., 1997: 396).
The aims include reducing waiting times for pedestrians at traffic signals and giving them priority in the allocation of time at junctions. This improvement for pedestrians needs to be achieved without increasing delays (and costs) to essential road users as congestion and unreliability of journeys add to the cost of business ([34] Lyons et al., 2001: 346).
It may be that automatic detection is the best approach, if a technology can be developed that is both reliable and selective in the detection of pedestrians. Video, infrared, microwave and ultrasonic detection technologies all hold promise ([61] Yauch & Davis, 2001: 34).
The research also noted variations in speeds for other classes of pedestrians (such as the elderly) and noted the need to consider these classes in designing signal timing ([29] LaPlante & Kaseser, 2004: 37).
Therefore, it is recommend that both the draft accessible guidelines and MUTCD use a 3.5 ft. (1.1 m)/sec. minimum walking speed across the street itself (curb-to-curb) for determining the pedestrian clearance interval and a 3.0 ft. (0.9 m)/sec. walking speed across the total crossing distance (top of ramp to far curb) for the entire walk plus pedestrian clearance signal phasing. In any case, the minimum walk signal indication still should be 4 sec. ([29] LaPlante & Kaseser, 2004: 40).

One important issue is to adapt the green light period to the walking speed of older people. Experiments have shown that less than 10% of the older test persons had a walking speed that is considered as a normal walking speed ([28] Langlois et al., 1997; Zegeer et al., 1994) and that this should be taken into consideration when planning for older pedestrians (Zegeer, Stutts, Huang, Zhou, & Rodgman, 1993). This is not only because of physical deficiencies but it is shown that it takes more time for older people to perceive and react upon light signals as well as traffic ([47] Oxley et al., 1997; Risser, 1988; Sparrow, Bradshaw, Lamoureux, & Tirosh, 2002; Staahl, 1986 in: [9] Bernhoft & Carstensen, 2008).

Countdown timers which display the time remaining to complete a crossing by a pedestrian are in use or being tested currently in US. However, it is difficult to find evidence in the literature to suggest that countdown timers informing pedestrians how long they must wait before the green

man is displayed have been used or evaluated elsewhere. In Istanbul, timers similar to those examined here are used for vehicles giving the time remaining for both red and green ([26] Keegan & O'Mahony, 2003).
Van Houten and Malenfant (1999) report the evaluation of the use of a digital LED -Walk-countdown time unit in Canada. In this case, the unit displays the number of seconds left for pedestrians to cross ([26] Keegan & O'Mahony, 2003).

Recently, technology has allowed the experimentation with pedestrian displays. The pedestrian signal countdown device, which provides a digital countdown clock in conjunction with a standard Hand/Man display, gives a "time remaining" indication to pedestrians and has been implemented in experimental installations in numerous cities ([61] Yauch & Davis, 2001: 34).
The City of Portland, OR, USA, has been using microwave detectors to detect pedestrians in the crosswalk. The city sets the Flashing DON'T WALK interval based upon a 4-fps walking speed; if a pedestrian is detected in the crosswalk at the end of the pedestrian clearance interval, the interval is extended to a maximum based upon a 3-fps walking speed ([61] Yauch & Davis, 2001: 34).

Some of these flaws already have been recognized, as evidenced by the provision of a second design walking speed to accommodate older pedestrians and the development of passive pedestrian detection devices ([19] Goh & Lam, 2004: 28).
The refuge-to-refuge section of the crosswalk is of interest because pedestrians often have to wait in-between the opposing light rail tracks due to the large volume of pedestrians using the crosswalk ([19] Goh & Lam, 2004: 28).

Action 13: Automated Demand-Responsive Crossings. Demand-responsive signals are common for regulating motorized vehicle traffic because they improve capacity of crossings and reduce waiting times. When implemented on pedestrian crossings, they should be able to adapt the green signal time to the walking speed of pedestrians, extending green for slow walkers. A criterion for maximum pedestrian waiting times should be built-in; it should result in fewer pedestrians having to wait. Finally, crossing should be made without a possible conflict with turning vehicle traffic (electronically-sensed signalized crossing; detector for pedestrians waiting; detector for pedestrians crossing) ([60] Yannis, 2007: 42-46).
* Full signalization: All pedestrian signals should now be timed using the new MUTCD pedestrian walking speed of 3.5 feet per second (1.05 m per second) to set the Flashing Don't Walk pedestrian clearance time and 3.0 feet per second (0.9 m per second) to determine the total Walk/ Flashing Don't Walk time.
Countdown clocks: The new MUTCD will not only require countdown clocks at all new pedestrian signal installations, but there will be a 10-year compliance date for retrofitting all existing pedestrian signal locations, finally correcting the longstanding confusion surrounding the traditional but counter-intuitive Flashing Don't Walk ([30] LaPlante, 2008: 27).

One important issue is to adapt the green light period to the walking speed of older people. Experiments have shown that less than 10% of the older test persons had a walking speed that is considered as a normal walking speed ([28] Langlois et al., 1997; Zegeer et al., 1994) and that this should be taken into consideration when planning for older pedestrians (Zegeer, Stutts, Huang, Zhou, & Rodgman, 1993). This is not only because of physical deficiencies but it is shown that it takes more time for older people to perceive and react upon light signals as well as

traffic ([47] Oxley et al., 1997; Risser, 1988; Sparrow, Bradshaw, Lamoureux, & Tirosh, 2002; Staahl, 1986 in: [9] Bernhoft & Carstensen, 2008).
Thus, the recommended walking speed and the corresponding timing of traffic lights in areas with large numbers of older persons should be modified to reflect the range of abilities among older pedestrians ([28] Langlois et al., 1997: 396).

Pedestrian detection (prolonging the time to cross the street) is desirable in complex situations ([7] AVVb).

Based on this study (recommended walking speeds Gates, Noyce, and Bill, 2006) the researchers recommend the following.

- a walking speed of 4.0 ft/s is appropriate only for locations with very few older pedestrians, assisted children, or disabled persons, such as college campuses.
- a walking speed of 3.8 ft/s is recommended for timing pedestrian clearance intervals at locations with normal pedestrian demographics (i.e. downtown areas, shopping areas, most neighbourhoods, schools areas) or location where the age or physical status of the pedestrian population is unknown.
- when the proportion of pedestrians over the age of 65 exceed 20%, 30%, 40%, and 50% of the total pedestrians at a location, walking speeds of 3.6, 3.5, 3.4, and 3.3 ft/s, respectively, are recommended.
- a walking speed of 2.9 ft/s is recommended for intersections where nearly all of the pedestrians are over age 65.

Reduce delays

The application of detectors to pedestrian signals cannot solve all the problems inherent in signals, nor can it completely eliminate conflicts or accidents. Except in very low flow situations, where signals are not normally suitable, it is not possible to eliminate delays to pedestrians and vehicles. In the last resort, the determination of how much signal time is to be allotted to pedestrians and the weights given to pedestrian safety and delay as opposed to vehicle delay are outcomes of the political process. But detection can help to redress the balance in favour of pedestrians. The very act of having to push a button to obtain recognition of their presence indicates the current second-class status of pedestrians. In addition, detection is a requirement for making signals more intelligent, for such intelligence requires knowledge of current demand. Pedestrian pre-arrival detection, as used here, can be applied to the fine-tuning of signals. Providing pedestrian stages only when they are needed, giving more prompt activation, extending the pedestrian stage so that late arrivals do not have to wait a whole signal cycle, and taking the size of pedestrian demand into consideration. The fact that the comparatively small manipulations of the signals discussed here produced discernible benefits should encourage the general use of these systems. It should also encourage further experimentation with signal timings in order to obtain additional benefits in terms of pedestrian safety and comfort, as well as the development of more extensive applications covering urban corridors or areas ([12] Carsten et al., 1998).

Reducing the cycle length ([26] Keegan & O'Mahony, 2003).
Intelligent traffic signals ([54] Sisiopiku & Akin, 2003).
At most crossings, vehicle precedence is retained during periods when vehicle flow is sufficiently low for pedestrians to identify gaps in vehicle arrivals in which to cross the road. Current

operating strategies impose substantially higher delays on pedestrians who obey signal indications. Reduction of such delays would encourage pedestrians to use the facility correctly for increased safety ([34] Lyons et al., 2001: 347).

Skills/abilities

While poor driving behaviours and engineering strategies are important, the behaviours of pedestrians are thought to be factors in pedestrian/ motor vehicle incidents, because in most cases, data from police generated traffic reports show that mistakes or illegal actions by drivers are not mentioned.11 Correcting unsafe pedestrian behaviours would be a less expensive way to reduce pedestrian injury and death rates than are engineering changes. Important pedestrian behaviours that can be factors in fatal and non-fatal crashes include such things as the improperly crossing of a roadway, inattentiveness, and failure to obey traffic signs ([11] Bungum et al., 2005).

There was also a publicized law enforcement intervention in effect at the time of data collection. It was reported that at least 58 tickets and 12 warnings to motor vehicle operators were written. Ironically there were no tickets issued to walkers.22 This finding is disappointing as some research suggests that enforcement of laws addressing pedestrian behaviour may be effective at improving street crossing cautionary behaviours ([11] Bungum et al., 2005).

While there is no single strategy that will reduce pedestrian injuries and fatalities, a comprehensive approach that includes engineering, enforcement and education, of both drivers and pedestrians is suggested.3 Again, because engineering changes are often expensive and enforcement is spotty and inconsistently applied, the education tactic is one that might be effective because research shows that at the time of pedestrian/car encounters the pedestrian is likely to be taking risks while crossing the street.3 Because being distracted was associated with displaying less caution in the present study we suggest that pedestrian education efforts that highlight the importance of displaying caution while crossing the street and the value of undistracted walking in traffic be initiated ([11] Bungum et al., 2005).

In conclusion, the present results have a number of implications for those who seek to reduce pedestrian accidents and casualties. The results revealed perceived behavioural control to be the strongest predictor of road crossing intentions, thus indicating that attempts to influence perceptions of control in potentially dangerous road crossing situations may be an important avenue to pursue. According to Ajzen (1991), perceptions of control may be based on both external (e.g. opportunities, constraints) and internal (e.g. self-efficacy, skills) factors.

Instead, it may be more profitable to attempt to address pedestrians' attitudes towards road safety (Quimby and Drake, 1989) by focusing on internal control factors. This may involve making pedestrians more aware of the difficulty of, and risks associated with, crossing the road in potentially dangerous situations in comparison with the use of road crossing facilities. Such an approach may encourage safer road crossing behaviour and, given that self-identity is seen to be partly based on the repeated performance of behaviour (Charng et al., 1988), instil a more safety-conscious approach to road crossing ([17] Evans & Norman, 1998: 488).

Although the use of markings and signs prompting pedestrians to look for turning vehicles has been shown to be effective in reducing conflicts and may be warranted and appropriate at certain intersections, the wide-scale implementation of these prompts would prove costly. A more economical way to increase pedestrians' observing behaviour would be to incorporate the prompt as part of the pedestrian signal. Modifying existing signals would require adding a third pedestrian signal head. A more cost-effective method would be to incorporate an unambiguous

prompt as part of the pedestrian signal head display. One way to accomplish this would be to employ a light-emitting-diode (LED) pedestrian signal head and add animated eyes that scan from side to side at the start of the WALK indication. This study was designed to evaluate the use of such a display ([24] Van Houten et al., 1999: 30).
During the baseline condition, the percentage of pedestrians not looking for turning vehicles averaged 32 percent at the Fort Harrison site and 26 percent at the Garden site. Overall, introduction of the LED signal head without the EYES display at the Fort Harrison site produced no change in the percentage of pedestrians not looking for vehicles. When the EYES display was introduced prior to the start of the WALK indication, the mean percentage of pedestrians not looking for turning vehicles decreased to 10 percent at the Fort Harrison site and to 5 percent at the Garden site ([24] Van Houten et al., 1999: 32).
Introduction of the concurrent EYES display and WALK indication further reduced the percentage of pedestrians not looking for turning vehicles to 3 percent at both sites. Repeating the EYES display every 9.5 s produced little change in the percentage of pedestrians not looking for vehicles at the start of the WALK indication. Six months later, the percentage of pedestrians not looking for vehicles still was about 2 percent at both sites ([24] Van Houten et al., 1999: 32).
During the baseline condition, the percentage of pedestrians not looking for turning vehicles averaged 18 percent at the Fort Harrison site and 16 percent at the Garden site. Introduction of the LED signal head without the EYES display at the Fort Harrison site produced no change in the percentage of pedestrians not looking for turning vehicles. When the EYES display was introduced prior to the start of the WALK indication, the percentage not looking for turning vehicles decreased to 11 percent at the Fort Harrison site and to 5 percent at the Garden site ([24] Van Houten et al., 1999: 34).
Introduction of the concurrent EYES display and WALK indication further reduced the percentage of pedestrians not looking for turning vehicles to 6 percent at the Fort Harrison site but did not produce a further reduction at the Garden site. The repeating EYES display further reduced the percentage of pedestrians not looking for turning vehicles to 3 percent at the Fort Harrison site and to 2 percent at the Garden site. Six months later, the percentage of pedestrians not looking for turning vehicles was about 3 percent at the Fort Harrison site and 5 percent at the Garden site ([24] Van Houten et al., 1999: 34).
Generally, pedestrians do not feel safe in a roadway environment nor do they expect drivers to go out of their way to stop for them. As a countermeasure, pedestrians should be made aware of the meaning of pedestrian signals. (Many pedestrians were confused about the meaning of the flashing DON'T WALK sign.) If a local community does not have the resources for a comprehensive awareness campaign, the installation of placards explaining the meaning of pedestrian signals can be useful ([51] Redmon, 2003: 29).

- Improve road user behaviour through education, enforcement, or social measures considered as indispensable elements of traffic safety policies complementing technical measures ([60] Yannis, 2007: 41).

Studies of training young children to cross the road safely using actual (Mohr et al., 1983; Yeaton and Bailey, 1978) or simulated roads (Demetre et al., 1993; Young and Lee, 1987) have tended to produce initially promising but often transitory effects, although in one study retraining after 1 year tended to re-establish skills which had fallen below a satisfactory level (Yeaton and Bailey, 1978). These findings indicate that current approaches to training young children safely to cross the road are not sufficient on their own to ensure children's safety. Perhaps through a better understanding of the information children use in making judgements and setting thresholds it might be possible to develop ways of enhancing their judgement skills and, thus, their safety. These could then be combined with programmes that teach safe route and crossing-site selection (e.g. Ampofo-Boatang et al., 1993) to provide comprehensive child pedestrian skills. However, environmental variables, such as vehicle speed, traffic density, and road width need to be considered as well ([13] Connelly et al., 1998: 450-1).

Previous research also points at the benefits of giving the older pedestrians a better understanding of the functions of a light signal. For example, this can improve their readiness for finalising their crossing although the light has changed to red (Solvi, 1988). Training older road users in judging vehicle speed is another possibility (Oxley & Fildes, 1995). On the other hand, efforts should also be made to enhance the drivers' perception of slowly crossing older pedestrians ([9] Bernhoft & Carstensen, 2008).

Some work has been done in evaluating changes in pedestrian behaviour such as that by Siques (2002) on light rail transit crossings in response to pedestrian automatic gates, a pedestrian warning device (flashing lights) and a 'look both ways' warning device ([26] Keegan & O'Mahony, 2003).

Animated signals, including one that incorporates a pair of eyes that alternate to the left and right to indicate the need to watch for traffic, are also being used in experimental programs ([61] Yauch & Davis, 2001: 34).

There are different prompts (painted or sign). For example the prompt sign 'Extend hand to cross' is used in crossings ([52] Retting et al., 1996: 28).

Older adults could perhaps benefit most from strategies designed to encourage pedestrians to look for turning vehicles. People 65 and older have about twice the pedestrian death rate of younger age groups, and have a higher proportion of fatal crashes at intersections ([52] Retting et al., 1996: 35).

Area 4: Education and Enforcement

Action 21: Educating Road Users in General People have to understand the language of roads and road users as well as traffic rules (formal and informal ones) and have to be aware of the importance of safe behaviour (for themselves as well as others). Traffic education largely aims at improving behaviour by providing information (provisions in general traffic education; provisions in advertising campaigns) ([60] Yannis, 2007: 42-46).

Action 23: Educating Pedestrians. Pedestrian education, starting in families and at school, often teaches defensive strategies and stresses avoidance actions. It also should aim at self-assured behaviour, including clear decision-making and direct, outspoken communication with drivers (education of pedestrians).

Action 24: Educating Special Groups of Pedestrians. This action should aim at improving special groups' mobility by teaching adequate strategies, without curtailing their freedom of movement (guidelines/training for the blind/ill-sighted; education for elderly pedestrians; education for mentally handicapped people; education, training and publicity for children) ([60] Yannis, 2007: 42-46).

Previous research also points at the benefits of giving the older pedestrians a better understanding of the functions of a light signal. For example, this can improve their readiness for finalising their crossing although the light has changed to red (Solvi, 1988). Training older road users in judging vehicle speed is another possibility (Oxley & Fildes, 1995). On the other hand, efforts should also be made to enhance the drivers' perception of slowly crossing older pedestrians.

Swedish research points at an expected rise in the rate of yielding towards older pedestrians, if pedestrian crossings are marked and speed humps are located at a longer distance from the marked pedestrian crossing (compared to speed humps close to the crossing) (Leden, Gaarder, & Johansson, 2006 in: [9] Bernhoft & Carstensen, 2008).

The Dutch program 'Duurzaam Veilig' recognizes the importance of continuously training road users and giving them information. Also the design of the road is important. If the design of a road is recognizable road users know what to expect. Research has shown that people make fewer mistakes when they have to react to traffic situations they expect than to situation they don't expect (Theeuwes & Hagenzieker, 1993 in: [58] SWOV, 2007b: 3). Road users can then act on their skill.
Besides the forgiving nature of the environment there is also the forgiving nature of other road users. The more skilled road users can help the less skilled road users by showing forgiving road behaviour ([58] SWOV, 2007b: 4).

Especially for people who are not that mobile there should be enough resting possibilities. At least every 200 m there should be a bench or another resting possibility ([36] Methorst, 2003a: 11).
At the European level work is begin conducted on the introduction of DRL (Daylight Running Light); this makes pedestrians less conspicuous and cars easier to see ([38] Methorst, 2003c: 184, 186)

Safety
In relation to the role of external factors, it may be possible to change the road environment through engineering interventions so that it becomes harder to cross the road in potentially dangerous situations and easier to use available road crossing facilities. However, such interventions may be counterproductive. Research suggests that while remedial treatment at accident blackspots reduces in the number of accidents at the treated site, there is often an increase in accidents in the surrounding area (Ebbecke and Shuster, 1977; Boyle and Wright, 1984 in: [17] Evans & Norman, 1998: 488).
Interventions to improve the safety of older pedestrians have been shown to substantially reduce traffic-related deaths and increase the independence and wellbeing of the urban elderly. Implementation of these interventions, however, is not widespread. With the aging of the US population, further attention must be paid to this important public health problem ([28] Langlois et al., 1997: 396).
The proposed alternative strategies are based on the assumption that it is possible to identify, in advance, a sequence of vehicle arrivals at a midblock signalled pedestrian crossing which the average pedestrian would perceive as a crossing opportunity. Enhanced strategies can be more responsive to pedestrian demand at minimal expense to vehicle occupants by making effective use of periods of low vehicle flow ([34] Lyons et al., 2001: 347).

During the baseline condition, the percentage of conflicts averaged 2.7 percent at both sites. Introduction of the LED signal head without the EYES display at the Fort Harrison site was not associated with a decline in conflicts. Introduction of the EYES display just prior to the start of the WALK indication reduced conflicts to 0.6 percent at the Fort Harrison site and to 0.4 percent at the Garden site. Incidence of conflicts remained low after introduction of the concurrent

EYES display and WALK indication and the repeated EYES display during the WALK interval and during six-month follow-up observations ([24] Van Houten et al., 1999: 32).
During the baseline condition, the percentage of conflicts averaged 2.7 percent at the Fort Harrison site and 2.3 percent at the Garden site. Introduction of the LED signal head without the EYES display was not associated with a decline in conflicts. Introduction of the EYES display just prior to the start of the WALK indication was not associated with a change in the percentage of conflicts at the Fort Harrison site but was associated with no conflicts at the Garden site. Introduction of the concurrent EYES display and WALK indication produced little change at either site. However, the repeating EYES display during the WALK indication further reduced conflicts to 0.6 percent at the Fort Harrison site, while no conflicts were observed at the Garden site. During the follow-up period six-months later, no conflicts were observed at either site ([24] Van Houten et al., 1999: 34).

Consideration should also be given to the cycle-by-cycle restriction of left turns when pedestrians are occupying the conflicting crosswalk. This would involve the development of a new left turn display that provides for both protected-permitted and protected-only operation- again, an opportunity for new display technology to assist in resolving pedestrian concerns.
There has also been some experimentation in variations in pedestrian signal operation. Many agencies have tried starting the WALK display a couple of seconds before the parallel vehicular green is displayed, thus giving pedestrians a chance to get out and claim the right-of-way in the crosswalk.
Finally, restrictions on the use of right turn on red should be considered at prime pedestrian locations ([61] Yauch & Davis, 2001: 35).

RTOR can be prohibited either at all times, during specified hours, or when pedestrians are present. Restricting RTOR at all times generally is limited to intersections where design features or other factors may increase the danger of allowing motorists to ever turn right on red. These include limited sight distance, unusual geometry and high traffic speeds on the intersecting street. The practice of restricting RTOR during specified hours or when pedestrians are present is more common in central business districts and in other dense urban areas because of significant variation in traffic volumes and pedestrian activity. The latter option gives drivers discretion to determine when pedestrians are present and is therefore less restrictive than the former, which is an absolute restriction during the specified time periods ([53] Retting, 2002: 32).
Traffic signs prohibiting RTOR during specified hours were very effective at increasing driver compliance with stop lines, reducing the number of drivers turning right on red without stopping and reducing the number of pedestrians yielding the right of way to turning vehicles. Signs giving drivers discretion to turn right on red based on whether pedestrians are present were not very effective. Restrictions on RTOR during the daytime period generally would coincide with hours when most pedestrian crashes occur. Stutts et al.10 reported that nearly 80 percent of intersection crashes involving pedestrians and turning vehicles occurred between 6 a.m. and 6 p.m., and 95 percent occurred between 6 a.m. and 10 p.m. RTOR restrictions and other countermeasures can help prevent more than 27,000 pedestrian crashes that occur at intersections each year in the United States ([53] Retting, 2002: 35).

Getting engineers and planners to think of pedestrian accommodation and safety in designing roadways and other transportation facilities ([51] Redmon, 2003: 26).

Both pedestrians and drivers indicated that when a driver makes a right turn on a red signal or a left turn at an intersection (on a green signal), the driver typically is looking for oncoming vehicles and a gap in traffic rather than for pedestrians in the crosswalk. Some obvious countermeasures include prohibiting a right turn on red or prohibiting a right turn on red when pedestrians are present. Dynamic "No Right Turn on Red" signs, which are electronically activated only when a pedestrian is crossing, also may be effective ([51] Redmon, 2003: 28).
To protect pedestrians when drivers make a left turn, engineers might consider adding a protected left turn with an arrow indication rather than just a green signal ([51] Redmon, 2003: 29).

The research team recommended the addition of red signal or beacon devices to the engineer's toolbox for pedestrian crossings. The study results indicated that all red signal or beacon devices were effective at prompting high levels of motorist compliance on high-volume, high-speed streets. However, only a traffic signal is currently recognized in MUTCD, and the current pedestrian signal warrant is very difficult to meet.
In the current situation, engineers are unable to easily employ traffic control devices that appear most effective for pedestrians on wide, high-speed streets. The research team recommended the inclusion of a new type of highway traffic signal in MUTCD called "pedestrian beacon." Pedestrian beacons would have different signal operation modes than traditional traffic control signals and would include the red signal or beacon devices that this study found most effective on high-volume, high-speed roadways ([18] Fitzpatrick et al., 2007: 36).

Measures that could be envisaged to reduce the problems were classified in the following categories:

- Reduce excessive speeds of motor vehicles on roads likely to be crossed (or shared) by pedestrians to reduce stopping distances and, if a pedestrian accident does happen, to minimize its consequences.
- Reduce conflicts between pedestrian flows and motorized traffic, thus reducing exposure, through the segregation of parts of the pedestrian network.25
- Facilitate and protect crossing a stream of vehicular traffic, as a majority of pedestrian accidents involve pedestrians crossing at random locations ([60] Yannis, 2007: 41).
- Solve problems of special pedestrian groups, such as children, elderly and handicapped people, by providing acceptable levels of service to those road users over the pedestrian network and, more specifically, in areas they particularly frequent or with high pedestrian concentration ([60] Yannis, 2007: 41).

Careful design of signal phasing plans and proper installation of signs can greatly help to improve travel conditions for pedestrians and turning motorists alike. Furthermore, it is recommended that additional surveys be conducted to examine differences between drivers and pedestrians regarding right of way at intersections ([54] Sisiopiku & Akin, 2003).
Swedish research points at an expected rise in the rate of yielding towards older pedestrians, if pedestrian crossings are marked and speed humps are located at a longer distance from the marked pedestrian crossing (compared to speed humps close to the crossing) (Leden, Gaarder, & Johansson, 2006 in: [9] Bernhoft & Carstensen, 2008).
There is currently some interesting research activity underway focusing on pedestrians. A recent study by Van Derlofske et al. (2003) looks at the impact of in-pavement flashing warning lights on pedestrian crossings to warn drivers about pedestrians crossing ([26] Keegan & O'Mahony, 2003).

When pedestrians use sidewalks and cross at designated locations, the separation of pedestrians and vehicles increases, and thereby pedestrian–vehicle conflicts are minimized. In this context, researchers have always been desirous of designing pedestrian crossings that are responsive to pedestrian needs and thus improve pedestrian safety and comfort ([54] Sisiopiku & Akin, 2003). Pedestrians are supposed to register their demand manually by activating the push-button when they wish to cross a street in a conflict-free phase ([54] Sisiopiku & Akin, 2003).
To improve the situation, leading pedestrian intervals may need to be considered when significant turning vehicular and/or pedestrian crossing volumes exist. Leading pedestrian intervals are expected to assist in reducing the number of conflicting movements with a potential to improve safety as well as pedestrian crossing compliance. Significant enhancement of pedestrian traffic flow may be possible through signal coordination (Virkler, 1998) ([54] Sisiopiku & Akin, 2003).
The research team recommended the addition of red signal or beacon devices to the engineer's toolbox for pedestrian crossings ([18] Fitzpatrick et al., 2007: 36).
Pedestrian beacons would have different signal operation modes than traditional traffic control signals and would include the red signal or beacon devices ([18] Fitzpatrick et al., 2007: 36).

- Facilitate and protect crossing a stream of vehicular traffic, as a majority of pedestrian accidents involve pedestrians crossing at random locations.
- Improve visibility of pedestrians to drivers (and of vehicles to pedestrians) to avoid masking pedestrians and improve communication between pedestrians and drivers.
- Improve readability of the road environment for all road users to facilitate anticipation of changes in the driving situation and avoid wrong expectations ([60] Yannis, 2007: 41).
- Solve problems of special pedestrian groups, such as children, elderly and handicapped people, by providing acceptable levels of service to those road users over the pedestrian network and, more specifically, in areas they particularly frequent or with high pedestrian concentration.28 ([60] Yannis, 2007: 41).

Action 9: Channelizing Crossings. The aim of this action is to concentrate the meeting of pedestrians and vehicles to certain spots. Generally, these spots are determined by the needs and characteristics of vehicle traffic. Crossing mostly is channelized on wide traffic arterials with high intensities of pedestrians and vehicles or near special spots like schools etc. (barriers against crossing).
Action 10: Grade Separation of Crossings. Grade separation generally aims at safe and uninterrupted proceeding of vehicles and prevention of pedestrians crossing on unwanted spots. It may improve pedestrian safety if they axe not avoiding the crossing, which may easily be the case. Grade-separated crossing should be well planned and should offer a minimum resistance for pedestrians: low level bridging, no detour and no fear of assaults (pedestrian bridge/overpass; pedestrian tunnel/underpass; grade-separated crossing where vehicular traffic (not pedestrians) has to change levels (bridge or tunnel) ([60] Yannis, 2007: 42-46).
Action 14: Differentiated/Alternative Crossing Designs to Better Suit Special Groups. "Design for all" aims at serving all groups in society, regardless of age, strength, or physical health. Certain planning measures may be applied to enable special user groups to participate safely and comfortably in traffic (adjustment of signal timing; assuming lower walking speed; use of pedestrian traffic light at beginning of crossing; auditory indicator for the blind/ill-sighted' colour contrast for the ill-sighted; tactile indicator for the blind/illsighted; signal push-button at convenient height for wheelchairs) ([60] Yannis, 2007: 42-46).

Action 17; Making Pedestrians More Visible. Pedestrians may be masked during foggy or dark weather by obstacles and objects such as parked cars or by objects distracting attention (heavily lighted cars). Improving pedestrian visibility aims at improving pedestrian safety by facilitating the possibility of timely action, warning, or prevention on the part of the driver or the pedestrian. However, two unwanted effects should be warned against: first, if drivers can detect better, they may compensate by driving faster; second, some groups of pedestrians may feel insecure if they know that they are easily seen (such as women or older people in quiet environments) (fluorescent/retroreflective clothing; lay-by (inlet) for car parking or for bus stop; provision of adequate street lighting; provision of special lighting/improved lighting quality near intersections; zebras and other crossings; removal of visual obstacles) ([60] Yannis, 2007: 42-46).

Action 19: Making Vehicles More Visible/Noticeable. This action aims at better preventive action on the part of pedestrians. It puts the burden on pedestrians and may result in less care by drivers and higher speeds (daytime running lights; noticeability of electric and other "silent" vehicles; reduction of noise level from indoor sources) ([60] Yannis, 2007: 42-46).

Action 22: Educating Drivers. It is important to teach drivers to reckon with pedestrians and their characteristics and not expect all pedestrians to understand the rules and situations or to be able to make the right decision. Moreover, drivers should realize that very dangerous situations for pedestrians can easily be created. Driver education should aim at appropriate communication and behaviour toward pedestrians (appropriate driver training; rewarding safe drivers; changing behaviour of younger traffic participants toward the elderly) ([60] Yannis, 2007: 42-46).

Action 26: Special Protection for Children/Elderly. Children and older people are vulnerable, and special measures for these groups aim at improving their subordinate position. However, taking special measures for these groups also stresses their weakness and therefore should be limited (provision of crossing patrols; physical protection of crossing patrols ("Endlicharm"); supervision of children in vicinity of busy roads) ([60] Yannis, 2007: 42-46).

Other possible speed control measures include:

- Narrower travel lanes: Based on the results of a recent National Cooperative Highway Research Program study, 11-foot (3.3-meter [m]) or 10-foot (3.0-m) lanes in urban areas are just as safe as 12-foot (3.6-m) lanes for posted speeds of 45 mph (70 km/hr.) or less.6
- Road diets: A four-lane to three-lane road diet can work for average daily traffic volumes as high as 20,000. This makes the more prudent driver the "pace" car for that roadway and greatly improves left turning safety.
- Tightening corner curb radii: Selecting the appropriate design vehicle and using the minimum needed to provide the "effective" turning radius from the closest approach lane into any lane in the departure roadway will slow down turning vehicle speeds.
- Elimination of any free-flow rightturn lanes: This specifically includes freeway entry and exit ramp connections. Encouraging freeway speeds onto or off arterial streets is particularly dangerous for both pedestrians and bicyclists.
- Raised medians: Raised medians visually narrow the roadway and provide a median refuge for mid-block crossings.
- Median and parkway landscaping: Appropriate low-maintenance landscaping further visually narrows the roadway and provides a calming effect.
- Curb parking: Retaining curb parking provides for community access while creating a significant traffic calming effect.

- Curb bulb-outs: Where on-street parking exists, curb bulb-outs shorten pedestrian crossing distances, improve sight lines and help control parking ([30] LaPlante, 2008: 26-7).

Many of the suggested pedestrian crossing improvements flow directly out of the traffic speed control measures noted above. They include:

- Narrower travel lanes: Shorten the pedestrian crossing distance and roadway exposure time.
- Road diets: Reduce the number of lanes to be crossed.
- Tighter corner curb radii: Shorten pedestrian crossing distances and provide space for perpendicular curb ramps.
- Adding corner "pork chop" islands where design vehicle turning radii do not permit a small corner radius: Also shorten pedestrian crossing distances.
- Raised medians: Provide pedestrian refuge and allow pedestrians to cross half the street at a time.
- Curb bulb-outs: Shorten pedestrian crossing distances, improve sight lines and provide space for curb ramps.
- Continental-style crosswalks and pedestrian crossing warning signs: Effective for lightly-travelled arterials posted for urban speed limits.
- Pedestrian-actuated crosswalk warning signs: For heavier traffic flows.
- Pedestrian-actuated HAWK-style signals: Will be in the new Manual on Uniform Traffic Control Devices (MUTCD) ([30] LaPlante, 2008: 27).

Simplifying the road crossing task (for example, centre of the road refuges, median strips) are warranted in areas commonly frequented by older people ([47] Oxley et al., 1997: 846).

Furthermore, they suggest that, rather than placing the primary responsibility on the children to make better decisions, especially given the ineffectiveness of educational initiatives in the child pedestrian field, efforts should be directed toward reducing vehicle approach speeds. This can be achieved through enforcement of lower speed limits and by use of engineering solutions, such as speed humps and chicanes.

The findings of this study point also to a need for further research into the potential contribution to greater child pedestrian safety of narrowing of the roadway using kerb extensions into the roadway and safety islands in the centre of the road. The kerb extensions would be likely to provide a safe and unobstructed viewing point from which to make judgements of approaching traffic and also reduce the distance that children have to cross. Centre islands would help in the reduction of crossing distances and also provide a safe haven from which to make judgements for crossing the remaining half of the road, especially when traffic volumes are high. They would appear to have the dual benefit for child pedestrians of eliminating some of the complexity of trying to judge, from a distant kerb, safe gaps in traffic approaching from both directions before crossing the entire road, and of increasing pedestrian protection in the vulnerable road centre ([13] Connelly et al., 1998: 451).

In addition, efforts to implement complementary measures such as improved street environment, traffic calming schemes, better vehicle design, speed limit, and continuous driver and pedestrian/cyclist education may also contribute towards improving the safety of all vulnerable road users ([27] Kwan & Mapstone, 2004: 311).

Passive interventions that create a safer environment are most likely to be effective for preventing injuries. Improvements in older pedestrians' safety can best be achieved through combined interventions involving reduced traffic speeds, increased use of median strips or traffic islands in roadway design, and increased crossing times ([28] Langlois et al., 1997: 396).

Interventions to improve the safety of older pedestrians have been shown to substantially reduce traffic-related deaths and increase the independence and wellbeing of the urban elderly. Implementation of these interventions, however, is not widespread. With the aging of the US population, further attention must be paid to this important public health problem ([28] Langlois et al., 1997: 396).

Conflicts between pedestrians and vehicles can be reduced through physical separation, but this can be expensive and difficult to implement ([52] Retting et al., 1996: 28).

Both pedestrians and drivers indicated that when a driver makes a right turn on a red signal or a left turn at an intersection (on a green signal), the driver typically is looking for oncoming vehicles and a gap in traffic rather than for pedestrians in the crosswalk. Some obvious countermeasures include prohibiting a right turn on red or prohibiting a right turn on red when pedestrians are present. Dynamic "No Right Turn on Red" signs, which are electronically activated only when a pedestrian is crossing, also may be effective ([51] Redmon, 2003: 28).
To protect pedestrians when drivers make a left turn, engineers might consider adding a protected left turn with an arrow indication rather than just a green signal ([51] Redmon, 2003: 29).
The research team recommended the addition of red signal or beacon devices to the engineer's toolbox for pedestrian crossings. The study results indicated that all red signal or beacon devices were effective at prompting high levels of motorist compliance on high-volume, high-speed streets. However, only a traffic signal is currently recognized in MUTCD, and the current pedestrian signal warrant is very difficult to meet.
In the current situation, engineers are unable to easily employ traffic control devices that appear most effective for pedestrians on wide, high-speed streets. The research team recommended the inclusion of a new type of highway traffic signal in MUTCD called "pedestrian beacon." Pedestrian beacons would have different signal operation modes than traditional traffic control signals and would include the red signal or beacon devices that this study found most effective on high-volume, high-speed roadways ([18] Fitzpatrick et al., 2007: 36).

The Dutch program ‘Duurzaam Veilig’ aims at less easily making mistakes and offences or making the consequences of these mistakes or offences smaller. They do this by making the surroundings, like the road and vehicles, connect to what people can en provides support and protection. Besides that, people should be prepared for the tasks in traffic. People will be instructed and educated. The (un)safety of the behaviour of people should be checked ([57] SWOV, 2007a: 2).
Another vision is ‘shared space’. The vision is about the design of areas where people are staying (living?). These areas are shared between traffic and people and there are as little as possible traffic signs like road signs and road markings. People should deal with possible conflicts through eye contact. This would lead to a lower speed ([57] SWOV, 2007a: 4).

‘Traffic calming by lowering and controlling speeds on streets and in areas where pedestrians are present is an efficient way to increase safety and comfort for pedestrians besides car-free areas and separated walkways ([20] Gunnarsson (ed.), 2001: 3).
‘Where pedestrians and motor vehicles are mixed, the vehicle speed should be lowered to 30 km/h through traffic calming measures. Pedestrian crossings on street should be preferably at the same level as the pavement’ ([20] Gunnarsson (ed.), 2001: 28).

‘Pedestrian crossings should be signalized in cases where the pedestrians have more than two lanes to cross or the allowed vehicle speed is 50km/h or higher. The waiting time for pedestrians to cross should be minimised, and the available passing time should be adapted to the conditions of the elderly and disabled’ ([20] Gunnarsson (ed.), 2001: 28).

The built-up area should be designed as an area where people can stay, with the exception of the access roads ([36] Methorst, 2003a: 2).

Measures can be taken in the area of spatial design, but also in the area of legislation (rules for the use of facilities) or basic education: knowing the safest way to move, knowing the rules and having the right skills. Besides that the public space and especially the traffic infrastructure, can be designed in a better way. And finally people can take measure so the facilities will be used safely (road signs, traffic lights, looking after that the rules are followed) ([36] Methorst, 2003a: 5).
Pedestrian routes should be designed according to the needs of the most vulnerable user ([36] Methorst, 2003a: 8/10).

Where pedestrian routes cross one or more roadways there should be:
- good sight on the driving traffic (at 50km/h: 100 m)
- average waiting time of no more than 15 sec.
- maximum waiting time of nor more than 60 sec.
- freely crossing the street with 0.8m/sec (without being hindered) ([36] Methorst, 2003a: 10).

In areas where people live the road should be safe to cross at any point. There are barely zebra’s. Where traffic go faster than 30km/h at crossings it should be safe to cross. These crossing have a zebra and a ‘midblock’ ([36] Methorst, 2003a: 11).

Pedestrians on sidewalk shouldn’t be hindered by vehicles (parked or driving). The pedestrian part of the road should be recognizable separated from the road. The sidewalk can be higher of separated from the road by a strip of grass or bushes. Pedestrians should also be separated from bicyclers. For example by different colour or hight ([36] Methorst, 2003a: 11).

There should be rules about keeping the domain of pedestrians free of vehicles or other obstacles. Also about minimal standards of crossing arterial roads. Pedestrians should have priority at traffic lights (if there are no cars the traffic lights should be green for pedestrians). There should be a parking prohibition at pedestrian crossings (at minimal 2,5 sec sight) ([6] AVVa).

At the European level people work at the introduction of MVO (that motor vehicles should turn their light on during the day). Because of this a pedestrian can more easily and faster see a car. But pedestrians and cyclists can also stand out less because of this. It is unclear if pedestrians are helped by this measure ([6] AVVa).

‘Preventing collisions between fast and slow traffic is, therefore, one of the most important requirements for sustainable safe road use by pedestrians and cyclists. Other measure have to be sought in the ‘disarmament’ of the crash opponent’ ([64] Wegman & Aarts (ed.), 2006: 155).

The European Commission wants pedestrian-friendly car fronts and the introduction of blind spot mirrors. Urban parking policy means that walking distances are increasing, this is not flanked by pedestrian policy (comfortable, safe routes) ([38] Methorst, 2003c: 190).

Ahuja et al ([2] 2008a) looks at feasibility of providing Scramble signals (all red traffic and all green for pedestrians to encourage safer movements and diagonal shortest paths) in city centre intersection and proposed guidelines for their installation. Scramble crossing, which permit the diagonal crossing of pedestrians across the signalized intersection, have proven to be more efficient in managing the movement of pedestrians at such intersections compared to conventional perpendicular pedestrian crossings. Previous studies (Bechtel and MacLeod, 2003) reveal that the installations of Scramble signals at intersections were able to reduce the frequency of accidents by nearly 50% (see also issue 5).
The study indicates that Scramble signals are best suited when the flow rates correspond to 400 pedestrians per hour per direction ([2] Ahuja et al., 2008a).

The safety of pedestrians can be enhanced in a collision with a vehicle by the active hood lift system (AHLS). AHLS works by lifting up the hood of a vehicle to obtain the space to absorb the impact energy before the pedestrian’s head hits the hood in pedestrian-vehicle collision ([45] Oh et al., 2008: 936).

Unambiguous signs
If use of the buttons continues, they must be placed at a convenient, and standardized, location and have an increased target value to draw the pedestrian's attention. Pedestrians must understand why activation of the button is important and beneficial for them. Buttons must be reliable in operation; confirmation of the receipt of a call through an indicator light, similar to an elevator call button, would provide immediate feedback that the system is operational ([61] Yauch & Davis, 2001: 34)**.**
The order of information for pushbutton messages should be:
- Intersection identification;
- Intersection signalization (if remarkable); and
- Intersection geometry (if remarkable) ([8] Bentzen et al., 2004: 23).

APSs (accessible pedestrian signals) with speech messages may seem user-friendly, especially when evaluated in an indoor setting, away from loud traffic sounds and by people who are native English speakers. However, they will not solve all ambiguity problems that can occur.
Tones have been found to be a better way to provide real time information about walk signal status where signal speakers can be installed in locations that provide unambiguous information.7 Unambiguous information about which crosswalk has the walk signal can be provided when APSs are located on separate poles for each crosswalk, close to the curb and near the side of the crosswalk farthest from the centre of the intersection ([8] Bentzen et al., 2004: 23).
Pushbutton information messages using speech are an excellent way to provide intersection identification and signalization and geometry information. Street names also may be provided to pedestrians who are visually impaired using Braille and/or raised print. Pushbutton information messages are essential where speech walk messages are used. Unless pedestrians who are visually impaired know the name of the street they wish to cross, speech walk messages still are ambiguous ([8] Bentzen et al., 2004: 23).

Table 3. Examples of facilities improvements to enhance pedestrian safety and/or ability to cross the street.

Pedestrian measure/treatment	Comments
Raised medians or raised crossing islands	These can reduce pedestrian crash risk on multi-lane roads significantly.
Installing traffic signals with pedestrian signals, where warranted	Current MUTCD signal warrants should be re-evaluated to better consider pedestrian needs.
Curb extensions	Curb extensions shorten street crossing distance and improve visibility between pedestrians and motorists.
Reducing four-lane undivided road sections to three lanes (for example, two through lanes with dual left-turn lane)	Lane reduction treatments (also called "road diets") can result in space for adding sidewalks and/or bike lanes as well as lower speeds and reductions in motor vehicle crashes.[1]
Raised crossings (raised crosswalks or raised intersections)	Raised crossings can result in reduced vehicle speeds and elevate pedestrians in the street for better visibility.
Street narrowing measures	Examples include street narrowing, chicanes, slow points, or "skinny street" designs, which can reduce vehicle speeds.
Pedestrian-friendly intersection designs	Examples include mini-circles, diagonal diverters and/or tighter turning radii.
Adequate nighttime lighting for pedestrians	This is particularly important for marked crosswalks and crossings near churches, schools and community centers with nighttime pedestrian activity.
Increasing the frequency of two- and three-lane arterials when designing new street networks	The goal is to minimize the construction of multi-lane arterials (for example, roads with four lanes or more).
Using various pedestrian warning signs, flashers and other traffic control devices to supplement marked crosswalks	Many of these devices are discussed in "Alternative Treatments for At-Grade Pedestrian Crossings."[2] The effects of many experimental traffic control devices are not well known. According to MUTCD, pedestrian crossing signs should be used only at locations that are unusually hazardous or where pedestrian activity is not readily apparent.
Installing advance stop lines on multi-lane road crossings up to 30 feet in advance of a marked crosswalk, along with the sign, "STOP HERE FOR CROSSWALK"	This measure was found by Van Houten to result in vehicles stopping further back from the crosswalk, thereby improving sight distance for motorists approaching in adjacent lanes.[3]
Removing on-street parking on the approaches to uncontrolled crosswalks	This measure can improve vision between motorists and pedestrians and may be used in conjunction with curb extensions.

1. Zegeer, C.V. et al. "Pedestrian Facilities Users Guide—Providing Safety and Mobility." Washington, DC, USA, Federal Highway Administration: 2002.
2. "Alternative Treatments for At-Grade Pedestrian Crossings." Washington, DC, ITE Pedestrian and Bicycle Task Force, 2001.
3. Van Houten, R. "The Effects of Advance Stop Lines and Sign Prompts on Pedestrian Safety in Crosswalks on a Multi-Lane Highway." *Journal of Applied Behavior Analysis*, Vol. 21 (1988).

([66] Zegeer et al., 2004: 40).

Under the most typical signal mode-simultaneous presentation from both ends of the crosswalk-the best performance occurred when signals were placed with the loudspeakers near curb on outside of crosswalk line. In this case, a pedestrian could tell easily which of the two loudspeakers at the corner was active because each loudspeaker was close to the position of pedestrians waiting to cross at the associated crosswalk. Note that this was true despite the fact that both signals on the corner had the same sound ([5] Ashmead et al., 2004: 29).
This research indicates that if APSs are positioned close to the curb and near the side of the crosswalk farthest from the centre of the intersection typical simultaneous signals provide accuracy that is essentially equal to that provided by signals that alternate or that comes from the far end only, when APSs are in other locations on the corner. This is true when all signals have the same sound; therefore, users do not need to remember the association between travel direction and signal or know the direction of the crosswalk ([5] Ashmead et al., 2004: 29/30).

Many traffic engineering agencies have tried to address the pedestrians' confusion by the use of informational signs located at crosswalk ends, typically adjacent to the pedestrian push buttons ([61] Yauch & Davis, 2001: 34).
The Americans with Disabilities Act has also prompted interest in pedestrian indications that satisfy the needs of the visually and physically impaired pedestrian. Audio indications, including both tones and synthesized voice messages, have been used in some locations to address these concerns.11 Vibrating detector posts have also been used to communicate the start of the WALK interval to visually impaired pedestrians without adding to the sounds of the intersection ([61] Yauch & Davis, 2001: 34). BLIND
Accessible pedestrian signals (APS) now are available with a range of features and options, including the capability to produce speech messages ([8] Bentzen et al., 2004: 20).
Action 20: Making Signing/Marking More Visible/Comprehensible. Traffic participants have to select information when moving; road signs and road markings often are overlooked, especially when they are not expected or when they are badly situated. Better visible/comprehensible signing or marking for pedestrians aims at giving the right information at the right spot (or in the right time) and in a striking manner.32 Application of such measures is more limited in urban areas than in rural ones, especially for signing (which has significant space requirements) (location, size and reflectivity of sign /markings; legibility and messages of signs/markings; colouring of road surface/markings at zebra crossings) ([60] Yannis, 2007: 42-46).

Generally, pedestrians do not feel safe in a roadway environment nor do they expect drivers to go out of their way to stop for them. As a countermeasure, pedestrians should be made aware of the meaning of pedestrian signals. (Many pedestrians were confused about the meaning of the flashing DON'T WALK sign.) If a local community does not have the resources for a comprehensive awareness campaign, the installation of placards explaining the meaning of pedestrian signals can be useful ([51] Redmon, 2003: 29).

Blind or bad sighted people can locate themselves through natural points like front sides of houses, grass, bushes etc. Sometimes unnatural guides are necessary. These should at least be 60 cm wide and have a recognizable structure ([36] Methorst, 2003a: 11).
Drivers don’t always recognize danger. As a result the project WALCYNG make some suggestion under which automatic speed controls with camera’s and a maximum speed of 30 km/h in sojourn areas ([6] AVVa).

Good overview
Action 11: Shortening (Especially Uncontrolled) Crossings. Shortening crossings is a way to reduce pedestrian exposure because it aims at minimizing meeting time between pedestrian and vehicle. Moreover, it can result in better sight, simplification of the crossing task, shorter waiting times and, thereby, less risk-taking. The action is recommended on traffic arterials with moderate intensities and speeds of vehicle traffic (refuge; median opening; strip/short section of median; sidewalk extension; diagonal crossing) ([60] Yannis, 2007: 42-46).

Sidewalks
Action 12: Avoidance of Abrupt Level Changes. Abrupt level changes mostly appear as a separation of pedestrian and vehicle space, forcing pedestrians to bridge level differences. Especially for bad walkers and handicapped people, but also for people carrying dungs, these are real obstacles, impairing mobility and evoking hazards (stumbling and falling over curbs). Avoiding abrupt level changes aiming at improving proceeding for large groups of pedestrians can be welcomed. It should, however, safeguard against unintended use of pavements by cars or two wheeled vehicles. It also should maintain a clear difference between sidewalk and carriageway, especially for children (raised crossing; low curbs and mild gradients for pedestrians; ramp for wheelchairs/mobility handicapped; curb cut) ([60] Yannis, 2007: 42-46).
Action 15: Pedestrian-Friendly Walking Surfaces. Bad construction of the infrastructure may cause injuries to pedestrians (bumping, slipping, tripping, spraining, or falling). A pedestrian-friendly walking surface implies evenness, roughness, smooth gradient, obstacle-free space and absence of dirt, pits, holes, snow and ice (differentiated paving/contrasted surfaces; anti-slip surface of walking path (sidewalk or crossing); obstacle removal from sidewalks or footpaths; durable walking surfaces; ice tracks for pedestrians) ([60] Yannis, 2007: 42-46).
'Walkways and pavements should be free from obstacles, parked vehicles, advertisements etc. Special attention should be given to adapting walkways and pavements to the blind and to persons on wheelchairs, persons with prams and walking devices. The fronts of houses close to pavements should be free from obstacles. Steep sloped and steps should be avoided or modified, also high kerbstones' ([20] Gunnarsson (ed.), 2001: 28).

Walkways should be wide and high enough, well passable (even, not slippery and dense), usable for wheelchairs and baby carriages. All walkways should (on one or more place) be applied with lowered curbs. The curbs shouldn't be steeper than 1:20 ([7] AVVb).

A sidewalk should have an obstacle free zone of at least 1,50 m width and 2.20 m high. If more than 100 pedestrians use the sidewalk in one hour the width should be at 2.40 m. In a shopping street, pedestrians will stand still so the width should be at least 4.00 m. When there are maintenance duties pedestrians shouldn't be forced to use the road ([36] Methorst, 2003a: 10).
A sidewalk or path should be designed and managed to accommodate various uses and users, taking into account actual uses and conditions ([63] VTPI, 2008).

Convenience
Action 14: Differentiated/Alternative Crossing Designs to Better Suit Special Groups. "Design for all" aims at serving all groups in society, regardless of age, strength, or physical health. Certain planning measures may be applied to enable special user groups to participate safely and comfortably in traffic (adjustment of signal timing; assuming lower walking speed; use of pedestrian traffic light at beginning of crossing; auditory indicator for the blind/ill-sighted'

colour contrast for the ill-sighted; tactile indicator for the blind/illsighted; signal push-button at convenient height for wheelchairs) ([60] Yannis, 2007: 42-46).

Drunk

Strategies to reduce the number of crashes involving alcohol-affected pedestrians should aim to prevent pedestrians reaching high BACs and to prevent alcohol-affected pedestrians being exposed to traffic (Victorian Parliamentary Road Safety Committee, 1999). While responsible alcohol service courses have an effect on the behaviour of personnel serving alcohol, studies continue to find that a large proportion of clearly intoxicated individuals are served at licensed premises even when servers have attended such courses (Buka and Birdthistle, 1999; Donnelly and Briscoe, 2003; Stockwell, 2001; Wallin et al., 2002 in: ([31] Lenné et al., 2007: 751-2).

Strategies to reduce the number of crashes involving alcohol-affected pedestrians should aim to prevent pedestrians reaching high BACs and to prevent alcohol-affected pedestrians being exposed to traffic (Victorian Parliamentary Road Safety Committee, 1999 in: [31] Lenné et al., 2007: 751-2).

Lowering vehicle speeds in areas where alcohol-affected pedestrians may be present will reduce the risk for this group ([31] Lenné et al., 2007: 752).

Interventions that have to do with the forgiving nature of the environment are safe edges of the road (semi-concrete edge), obstacle free zones, or protected obstacles ([58] SWOV, 2007b: 2).

7.5 In general

The PROMISE project used cost-benefit analyses to identify cost-effective measures designed to improve safety and mobility for vulnerable road users. This European project across several member states found (1) that measures that improve conspicuity and visibility will often improve safety for all road users, but particularly for pedestrians and cyclists. An increases use of daytime running lights on cars, reflective devices worn by pedestrians and road lighting is encouraged. These measures are in many cases likely to give benefits that widely exceed the costs. (2) Measures that reduce driving speed, especially in urban areas, will improve safety, and sometimes mobility, for pedestrians and cyclists. Measures that reduce speed for motorists in urban areas will not always pass a cost-benefit test. The cost-benefit analyses presented by PROMISE are in most cases based on data taken from one country ([59] TRL, 2001: 4).

Pedestrian safety measures are best implemented if they result from a consistent and comprehensive policy rather than piecemeal, isolated improvements. Such a policy should be aimed at achieving an optimum balance, both internally (targeted at all four areas) and externally (taking into account the impact on other road users, in particular car traffic). Not only the effectiveness but even the characterization of restrictiveness and cost-effectiveness of several measures depends on their implementation policy.

Furthermore, mechanisms should be ensured for converting policy into practice at the level of street design in an effective and efficient manner. These go beyond the evident need for coordination among different levels of responsibility and scientific disciplines; it is important to also improve knowledge of the effectiveness of (sets of) safety measures, through follow-up of actual applications as well as a synthesis of existing research findings. Quantitative information, if

available, can lead to the incorporation of the acquired knowledge into a rational decision-making framework, in a systematic and convincing way.
Implementation of modern pedestrian safety policies and measures requires actions at the local (regional), national and international levels. Coordination is required not only among those levels but also within each one of them, especially between actors of different disciplinary backgrounds. Local authorities, which usually will be responsible for applying street-level measures, may need incentives (regarding financing and/or transfer of know-how) to adhere to policies formulated at higher levels ([60] Yannis, 2007: 46-7).
In order for complete streets to be truly effective, the following implementation measures should be considered:

- Rewrite and/or refocus agency policies and procedures to serve all modes.
- Rewrite and/or adapt design guidelines.
- Train and develop staff skills in serving all modes.
- Collect data on all users and modes for performance improvements ([30] LaPlante & McCann, 2008: 25).

There are many specific ways to improve walkability (ADONIS, 1998; Litman et al., 2000) Major categories include:

- Improved sidewalks, crosswalks and paths
- improved nonmotorized facility management and maintenance, including reducing conflicts between users and maintaining cleanliness.
- universal design (transportation systems that accommodate special needs, including people using wheelchairs, walkers, strollers and hand carts).
- provide pedestrian countdown signals, which indicate how many seconds are left in the walk phase ([35] Markowitz et al., 2006).
- Create pedways, which are enclosed urban walkways networks that connect buildings and transportation terminals. Provide covered walkways, loading and waiting areas, with shade from hot sun and protection from rain.
- Improve pedestrian accessibility by creating location-efficient, clustered, mixed land use patterns, with good road and path connectivity, and pedestrian-oriented buildings, reflecting New Urbanist design principles.
- Develop transportation access guides, which provide concise information for accessing a destination by walking, cycling and public transit, and facilities and services for people with special mobility needs.
- concentrate more activities into walkable commercial centres.
- street furniture and pedestrian facilities (e.g.,, benches, pedestrian-oriented street light, public washrooms, etc.).
- Design in a pedestrian scale, with shorter blocks, narrower streets, pedestrian-oriented buildings and street furniture.
- create more livable communities and more pedestrian-oriented streetscapes.
- traffic calming, speed reductions, streetscape improvements and vehicle restrictions.
- road space reallocation to increase the portion of public rights-of-way devoted to sidewalks.
- Active transportation encouragement programs.
- use multi-modal level-of-service indicators to evaluate walkability problems and negative impacts on pedestrian travel that can result from wider roads and increased motor vehicle traffic volumes and speeds ([63] VTPI, 2008)

A number of guides and resources including ADONIS (1998), Litman et al. (2000), Zeeger et al. (2002) and GDOT (2003) provide information on best practices for improving walkability and encouraging walking. These include:

- integrate nonmotorized planning into all transport and land use activities.
- educate all transportation professionals in nonmotorized transportation planning principles.
- fund nonmotorized planning at a comparable rate as other travel modes.
- insure that all roadways are suitable for walking unless it is specifically prohibited and suitable alternatives are available.
- use current planning practices and design standards, including universal design.
- include nonmotorized travel in transportation survey and models.
- create pedestrian-oriented centres and neighbourhoods.
- perform user surveys to identify problems and barriers to pedestrian travel.
- use traffic calming and other traffic control measures to make street environments safer and more pleasant for walking ([63] VTPI, 2008).

The PROMISE project classifies useful measures for implementation purposes in three categories related to cost and effectiveness, separately for technical and non-technical measures. The three categories are the following:

- low (or moderate) cost and high (or moderate) effectiveness
- high cost and high (or moderate) effectiveness
- low (or moderate) cost and low effectiveness.

Obviously, cost and effectiveness depend upon on the conditions of implementation.
PROMISE expects an effectiveness as follows for pedestrians. See for the measure table 4.4 Effectiveness of technical measures, page 75 to 77 ([42] NTUA, 2001).

7.6 PROMPT New means to promote pedestrian traffic in cities

Research project funded by the EC, 5th Framework-EESD, The city of tomorrow and cultural heritage.

The European PROMPT project explicitly identified ways and interventions to improve city living conditions and the quality of cities for pedestrians. These efforts were made in the context of the projects general goal to promote non-motorized transport in cities with particular focus on pedestrian traffic. The project included seven international partners lead by VTT Building and Transport, Transport and Logistics (Finland) and focused on how to promote walking. The following observations are based on PROMPT. Faced with the question how to promote walking, PROMPT discusses as follows ([50] Source: http://virtual.vtt.fi/virtual/prompt/english.pdf).
As a mode of transport, walking is very difficult to predict because so many different factors have an influence on it. The essential aspects for deciding to walk or to use some other means of transport are the ease of the trip, the distance to the target, the available means of getting there, the trip purpose, safety, comfort and the pleasantness of the itinerary, as well as the accessibility of the target. Furthermore, one also usually considers the possibilities of combining several different trips for several different purposes. Other decisive factors are one’s personal health and fitness, and anything to be carried.
Walking can be favoured, especially on shorter trips. Even for them, the use of one’s own car is the probable choice, if it seems to be more comfortable and practical. Unfortunately, most chil-

dren today are already accustomed to being taken to school by car, for several reasons. Walking can also be favoured as part of longer trips, such as work trips or trips to the city centre, if a good public transport service is available within short and comfortable walking connections. In this way, the use of public transport will also be promoted as an alternative to the use of one's own car.

In general, to promote walking means to improve all conditions for it. It is important that most of the factors affecting the decision are in favour of walking at the same time. For example, it is not sufficient that the route is short if it is not safe. Furthermore, awareness of the benefits of walking should also be increased through education and specific promotion campaigns.

- How to find effective means and guidelines for achieving these objectives is what PROMPT has particularly aimed at. The objective has been to find a variety of best practice examples and develop new tools and generic solutions to promote walking, to be offered to the decision makers, planners and designers. The scope of these tools and solutions ranged from problem identification to their solutions.

The PROMPT website provides an overview of relevant solutions for four out of these six need areas. These solutions are, in fact, recommendations including advisable interventions. Table X shows these advisable interventions in detail for four need areas.

A Addressing the need for physical and social space

A1 Give priority to pedestrians in transport planning
Give priority to pedestrians means to change the usual perspective of transport and land use planners: walking is one of the transport means, has to be considered as such and needs to be looked at as a privileged means of transport. In this sense, space has to be provided for, organized and designed.

A2 Organize the space
The supplied space has to be organized with pedestrians in mind, both for moving and for resting, either for the activities they have, or they wish to perform. Spaces must be connected in a dense network that allows pedestrians to walk along a continuous route that, providing differentiated spaces, fulfils all various needs.
A2.1. Simple, efficient and dense schemes
Pedestrian's movements are slow and need effort. The effort is highly dependent on the characteristics of the path such as height differences.
Recommendations:
A well-designed pedestrian network scheme must fulfil the following requirements:

- *Density of links:* a dense network allows users to always choose the shortest path to the destination, without excessive detours. Paths with outstanding appeal can be an exception to this rule. Detours can be a consequence of large building blocks, inaccessible areas or poor crossing facilities. These problems can be faced by creating shortcuts, using public space inside private buildings, and making methodical observations of users' behaviour.
- *Density of destinations and landmarks:* pedestrian networks must be short, or at least have to appear short to the users. To this aim, users should come across different points of interest along the paths: facilities, landmarks and attractions.
- *Legibility:* every "error" (in choosing the way) costs a lot of time and effort, therefore the

network topology should help pedestrians in easily finding their way. Bad legibility can be a consequence of irregular schemes, of long distances and large spaces. A rectangular grid gives the easiest orientation capability also to non-residents, and can also offer shorter routes, if complemented with short cuts.
- *Ease of use:* the effort needed to move around is not only dependent on the length of the path, since pedestrians, and in particular the elderly and disabled people, are very sensitive to its steepness or the presence of steps. When other solutions are not possible, mechanical aids, such as escalators, may be used.

A3 Living streets day and night
Streets can be alive day and night if a high quality of life is provided around the clock for every user of the public spaces, and, above all, pedestrians. This can be achieved by:
I. Providing enough housing and variety of facilities and meeting points in buildings along these streets and their close environment.
II. Secure and comfortable spaces between the private and public realms and by proper continuity and separation of those realms with varying levels of privacy.
A3.1 Enough housing and variety of facilities and meeting points in buildings along streets and their close environment
More detailed means for this are:
1. Mixed use and a guaranteed minimum share of flats
2. Social mixture of people and events
3. Public facilities in every sub-district
4. Multiple use of public spaces for unofficial activities
A3.2 Mixed use and a guaranteed minimum share of flats
Mixed use of buildings along the streets: sufficient share of flats on the ground and first floor and a high share of services and other activities.
Recommendations
- Minimum 50 % share of flats per sub-district
- Minimum 10 % share of facilities; shops, social services and meeting points
- Maximum length of uninhabited façades on the ground and first floors to be 50 m along 100 m of street.

Best practice example: The co-existence of flats, shops and restaurants keeps the streets alive day and night.

B Addressing the issue of interference with motor vehicles

In all developments, consider that you have to move as a pedestrian and not only as a car driver
This new approach calls for a complete re-thinking of the process, from the research to the implementation level. New solutions for mixed traffic and the co-existence of different modes of transport should be studied, aiming at a harmonic cohabitation of pedestrians with other street users. It must be based on equity in user repartition, so that everyone respects the needs of the others. In this way pedestrians will no longer become heavily injured. This approach also needs to be supported by analyzing the possibility of giving pedestrians general priority over traffic, at least in the city centres and the residential areas.
B1 Speed reduction of motor vehicles

The harmonic cohabitation of different road users cannot be ensured unless the speed of motor traffic is moderated. This is an essential condition for ensuring the safety of the most vulnerable road users, like pedestrians and cyclists. This would make it possible to share the road in a convivial manner, without a battle for the strongest. To begin with, speed should be reduced by the layout of the streets. This can have a major effect on user behaviour. Other possibilities are to create 30 km/h speed limit zones, even for the whole city, and to develop special mixed traffic areas or, as a last resort, to use police control.

B2 Mixed use zones

Description

In some places, such as residential or shopping districts, some countries have developed intermediary concepts between pure pedestrian precincts and 30 km/h zones. In these zones, space is shared between all users, but pedestrians generally have priority and the speed limit is 10 to 20 km/h. There are nuances between these concepts. Examples are:

- “Woonerf” streets (The Netherlands)
- “Home zones” (Great Britain)
- “Meeting zones” (“zones de rencontre”, Switzerland)
- “Natural” co-existence (Italy)

C Addressing the issue of poor natural, architectonic and psychological features of the environment

A green network in every city

The goal is that everyone can reach every part of the city on foot along pleasant paths with alternating "green" and" grey", and be independent of the car. The aim is to create or enlarge the green areas within the cities (so-called "green nodes"). These should be fairly shared out with regard to the main urban activities and residential areas. Further on, all these green nodes should be interconnected by green paths (so-called “green corridors”), specifically planned and designed for walking and cycling. Means of creating such a network are:

I. Built spaces interlaced with densely interconnected green nodes
II. Comfortable pedestrian paths to connect the green nodes
III. Water and green elements, with their seasonal variations, integrated in the design
IV. Variety in the design and use of the green areas
V. A clear hierarchy of the different green areas
VI. Diverse roles given to nature in cities

C1 Built spaces interlaced with densely interconnected green nodes

Description

A green network with a dense grid is an ideal scheme that has to be adapted to the local situations using the opportunities offered by the site and, at the same time, ensuring that every resident has direct access to this network. The objectives can be aimed at by:

1. providing a sufficient grid density
2. exploiting the existing natural green framework
3. exploiting urban wastelands, river banks and shores to create and enlarge the green areas
4. arranging the green spaces as closely as possible to the places of everyday life (maximum distance 200 m).

Recommendations for land use planning:

- Theoretical mean distance between two green areas should be about 400 metres.

- The catchment area of one green node should be about 200 metres all around it.

D Addressing the issue of poor environmental performance

D Integrate the pedestrian scale in city design
Pedestrians have to be at the centre of the planning and design of urban spaces. First of all, planners and decision makers have to think like pedestrians, wishing to be happy while walking. The solutions should meet the needs of all the pedestrian groups, especially the most vulnerable. Taking account of these needs will also serve all the other pedestrians. Both the physical and psychological needs should be met.
D1. Pedestrian-friendly design
The pedestrian scale can be taken into account separately in the design of space, furniture and detail, which all affect the pedestrian's perceptual world. The height of buildings, width of streets and squares, details of facades, furniture, plantations, etc., must be designed according to the pedestrian pace and angle of view, and should correspond to the pedestrians' expectations and desires.
D2 Pedestrian-based space design
Description
Pedestrian views should vary and be interesting - and even exciting - and correspond to the pedestrian pace.

Recommendations:
- Avoid designing too long and monotonous buildings.
- The needs of different pedestrian groups, especially vulnerable ones like elderly, children, etc., should be taken into account in the design.
- Provide interesting views through a combination of old and new elements.
- Provide exciting views by splitting the path into separate segments.
- Utilize the terrain and surrounding landscape for creating exciting and surprising views.
- Consider the walking experience as a "movie" with varying scenes.

([50] Source: http://virtual.vtt.fi/virtual/prompt/english.pdf)

7.7 Vulnerable Road Users

The Transport Research Centre AVV was commissioned by the Directorate General for Passenger Transport of the Ministry of Transport, Public Works and Water Management to establish a practicable basis for the development of an effective and efficient policy.
The report *Vulnerable Road Users* (2003) by Methorst ends with (provisional) recommendations concerning: basic principles for the policy that is to de developed; steps to a more effective and efficient approach; matters that should be included in a National Transport Plan with a view to improving the safe mobility of vulnerable road users and advisable measure at the national government level.

National Transport Plan

The fact that a National Transport Plan (NVVP) has to be developed offers a good opportunity to make a new beginning with the policy development concerning vulnerable road users, especially pedestrians, cyclists, moped riders, primary school children, secondary school children and elderly people. It is recommended that the National Transport Plan should include, as a minimum, the following points:

- Consultation with the partners about organisation of the planning process for spatial plans and the checking of the plans; Sustainable Safety phase 2; tightening/ adjusting regulations and guidelines; division of tasks in the areas of knowledge management and public support acquisition in relation to e.g. the Knowledge Platform Verdi (Traffic and Transport, Regional, Decentralised and Integrated)
- Continuous promotion of generic Sustainable Safety measures within the built-up area, which is the pre-eminent domain of vulnerable groups. The most important measures here are the creation and (re-)layout of residential areas as 30 km/h zones and provisions enabling pedestrians to cross main traffic arteries. Here, it is advisable to introduce uniformity of approach in complex situations
- Concentration of knowledge regarding vulnerable road users in one place (Vulnerable Road Users knowledge bank) and associated promotion of the establishment of a Vulnerable Road Users knowledge network (contacts in national/ local authorities and non-governmental organisations)
- Creation of a Vulnerable Road Users Forum, with the tasks of: exchanging and storing knowledge, detecting developments, producing outline policy proposals and obtaining public support for these
- Tightening of guidelines and recommendations for highways authorities on the basis of the available knowledge concerning the reduced task capabilities of specific groups

Inclusion of available knowledge about vulnerable road users in the education of traffic consultants, ergonomists, urban planners etc.

National government

With respect to the safe mobility of vulnerable road users, it is recommended that the national government should take the following responsibilities:

- To (continue to) create favourable conditions for the realisation of Sustainable Safety phase 2; to promote that priority is given to tackling the problems of vulnerable road users on main traffic arteries within the built-up area
- Development of a long-term policy regarding pedestrians, cyclists and elderly people, giving special attention to the road safety consequences of population ageing and increasing car and freight traffic
- Continuation of policy development and implementation with respect to road safety education (primary school, secondary school) and moped riders
- Encouraging other national/ local authorities and non-governmental organisations to fulfil their responsibilities within the framework of the National Transport Plan (NVVP) and Provincial Transport Plans (PVVP's), and promoting expertise in the commissioning of work at the local level
- Responsibility for knowledge management (collecting, making available and disseminating knowledge). It is recommended that a knowledge task force should be set up within the Ministry of Transport, Public Works and Water Management; this would take the necessary steps to fill in crucial knowledge gaps and make policy recommendations.

- Examination of general policy in terms of safety consequences, especially for vulnerable road users.
- Re-evaluation of regulations and enforcement of traffic legislation with a view to protection of vulnerable groups (e.g. emphasis on driving speeds within the built-up area, fines for failing to stop at zebra crossings, parking ‘for a moment’ on the footpath etc.)
- Rewarding of activities in the non-governmental field which encourage regional and local authorities to tackle problems.

Setting up a Vulnerable Road Users Forum, with the tasks of exchanging and storing knowledge, detecting developments, producing outline policy proposals and obtaining public support for these

Provinces, municipalities and non-governmental organisations
Regional and local authorities and non-governmental organisations play an extremely important role in enabling safe mobility of vulnerable road users. In the framework of the Planning Act, provinces are given the task of establishing the preconditions for the traffic and transport policy of municipalities in a Provincial Transport Plan (PVVP), which in principle comprises an elaboration of the agreements made in the National Transport Plan (NVVP). Translation of the results of this project into recommendations for measures at the regional and local levels and activities of non-governmental organisations is still to be carried out. This may be seen as one of the tasks of the aforementioned Vulnerable Road Users Forum ([38] Methorst, 2003c: 144-5)

7.8 OECD

The OECD reviewed the current safety situation of vulnerable road users. In chapter IX they describe some safety measures.

Many types of *“non-infrastructural” measures* to increase the safety of vulnerable road users can be distinguished. Given the limited time frame available to complete the study, it was not possible to fully document all evaluated measures. Only selected areas -- including education and training, measures to enhance visibility and conspicuity, and protective devices for cyclists (bicycle helmets) -- where promising advances are still anticipated, are discussed in the report (see Section VI.1).

When dealing with the issue of vulnerable road user safety, the emphasis is generally placed on the *training and education* of the vulnerable road users themselves rather than on alternative measures such as town planning, infrastructure facilities, or the behaviour of other groups of road users. Education is often put forward as an effective preventive measure. However, evaluating precisely the effects of educational programmes is difficult, i.e. in terms of accident involvement. Examples show that the effects of Traffic Clubs for children are still inconclusive. Contrary to the many educational programmes available for children, very few intervention programmes for elderly pedestrians and cyclists have actually been implemented. Although the evaluation of an education programme aimed at elderly pedestrians in Japan does not demonstrate an effect on accident involvement, a questionnaire study showed that participants in the programme were enthusiastic about it. Especially the practical approach was valued by the participants.

From the review on measures to enhance the *visibility* and *conspicuity* of pedestrians and cyclists, it appears that retro-reflective devices accentuating the form of the bicycle or person (pedestrian), and highlighting their movements, are the most capable of having these road users recognised as such. However, one should not rely on detection distances, because these are much longer than recognition distances, and usually lead to too optimistic findings regarding the conspicuity of materials. Furthermore, expectation is a very important factor in visibility: on average, when an observer knows what is ahead and where he should approximately encounter the "obstacle", it will be detected at twice the distance than when the observer does not have this information. Conspicuity aids alone are not sufficient to secure recognition of vulnerable road users. Other physical measures should indicate to motor vehicle drivers that vulnerable road users could be expected on certain roads. The most important problem is probably not the effectiveness of visibility aids but rather encouraging more widespread use of even the most basic aids in darkness. Only a small proportion of cyclists use their lights and conspicuity aids. For pedestrians, these devices appear to be used even less.

Prospective non-infrastructural safety measures for vulnerable road users are (see Section VI.2): *"life-long" traffic education* to be integrated with the more traditional areas of education, and involving not only teachers, but safety professionals, health professionals, as well as associations and the families; *training processes and networking* to be set up in order to provide adequate safety culture to the deliverers of education and keep their knowledge of accident factors and pedagogical approaches updated; guidelines to traffic education have already been produced; *education* programmes *for elderly* road users may be quite promising, provided they are based on a practical approach and rely on the active participation of the elderly in designing such programmes; greater use of *conspicuity aids* for pedestrians and cyclists, and promoting *acceptance* and use *of* bicycle *helmets* are still prospective measures in most countries, and should prove most useful. Improvement of *motor vehicle equipment* such as *speed limiters* and the use of new technologies such as *telematics* are also promising.

The *evaluated "infrastructural" measures* reviewed include essentially speed reducing measures for use in urban areas, various infrastructure facilities for cyclists, and specific elements of junction design (see Section VII.1).

The most efficient *speed reducing measures* are those that make driving above a designated speed physically impossible. A good example of this kind is the introduction of roundabouts. The safety benefits of roundabouts depend very much on the local conditions. Pedestrians and especially cyclists experience safety problems at the larger roundabouts. Integration of cyclist and car traffic at small roundabouts -- where they have to share the entrance, the circling area and the exit -- works well at low traffic volumes; at higher traffic volumes, a separate bicycle lane is recommended. Evaluations of series of roundabouts at successive junctions showed large reductions of the overall number of injury accidents and high cost-effectiveness, although the benefits were less for cyclists than for other road users.

Besides roundabouts, other good speed reducing measures are those that use differences in levels in order to slow down traffic, e.g. humps, elevated pedestrian and cycle crossings or elevation of the whole intersection. Well-designed humps have proven to be successful in ensuring traffic speeds under 30 km/h. Measures like narrowing the carriageway and installation of central pedestrian refuges do not actually, in a physical sense, force the vehicles to slow down, but they generate a speed reduction since the feeling of driving too fast is high, even at rather low speeds, when the environment gets close enough.

All forms of speed reducing measures have been implemented area-wide in many towns and cities, in traffic-calming schemes, 30 km/h zones in residential areas, or speed-reducing schemes on through traffic arterials in sensitive urban neighbourhoods. In addition, various forms of features aimed at emphasising local activities and the presence of pedestrians and cyclists, such as roadside planting or pieces of street furniture, special lighting or surfacing, etc. have also been used. Although evaluation of the effects of such schemes on accidents is not easy due to the heterogeneity of situations and of the combination of measures applied, as well as to the difficulty of defining control areas, follow-up of demonstration projects have shown good overall safety results, as well as other benefits in terms of local accessibility, mobility of the most vulnerable road users, environmental amenities, reduced noise and pollution. When planning traffic calming measures, care has to be taken however to avoid generating visibility problems.

The most common conflicting areas between motorised traffic and vulnerable road users are at *junctions*. To improve safety for cyclists at these locations, different means of making them visible have proven to be successful. Introducing an Advanced Stop Line for cyclists allows these road users to position themselves in front of drivers, which decreases the chances of the cyclists appearing "from nowhere". While cycle tracks have been found efficient in decreasing bicycle accidents on links, particularly on arterials, they create safety problems at junctions. Interrupting cycle tracks to let cyclists merge with motorised traffic before the junction makes road users more aware of each other before they reach the conflicting area. It has been found an efficient approach to reduce the risk of unexpected appearance and thereby improve safety. Based on the results of several studies, bi-directional cycle tracks should not be built even if they are cheaper than one-way cycle tracks on each side of the road. The main reason that bi-directional cycle tracks create problems is again because of expectation: drivers expect cyclists to appear from the "right" and not the "wrong" (in most countries left) direction.

At signalised junctions, pedestrian- and cyclist-*friendly control strategies and simple intersectional design* is important for safety. Red-walking is a major safety problem; it is quite common behaviour among pedestrians often caused by long waiting times. The accident risk for pedestrians crossing against red is on average 4.5 times higher than when crossing on green. Effort should be taken to design control strategies which minimise the waiting time for pedestrians or gives automatic green when they appear at the kerb. Giving pedestrians a split phase, or a green light for only half of their crossing, creates major safety problems: the risk of misunderstanding such a strategy is extremely high. It is especially dangerous when only the second part of the crossing shows green since cars to the near-side may approach at high speed. It is also recommended to make the pedestrian crossing as short as possible. Visibility and safety are improved if the pedestrian/cycle crossing is placed as close as possible to the junction.

As to *prospective "infrastructural" measures* (see Section VII.2), new technologies may be used to improve mobility and safety of pedestrians or cyclists at crossings, in particular mat and infra-red *detectors* applied to providing immediate green light to vulnerable road users approaching the kerb and lengthen the green light until all of them have safely completed their crossing; further experimentation is, however, needed. On a larger scale, implementation of *comprehensive* bicycle and/or pedestrian *networks* across towns or cities, with emphasis on continuity, comfort of use, and protection from motorised traffic, is a step towards a more balanced and equitable transport system and an essential component of any transport policy aiming at promoting non-motorised transport modes; design guidelines have already been produced.

Implementation of safety measures for vulnerable road users may be a complex process when changes in transport policies are involved or when solutions integrating physical and non-physical measures are chosen. A large number of partners are concerned and organisation of a budget for the road safety programme may involve several sources and management procedures. Good communication between partners is essential and co-ordination is needed and should be organised on the national as well
as the local level. A large part of the actions -- such as traffic education, programmes for infrastructure improvements, etc. -- rely on the participation of *professionals' networks*. As a consequence, it is also necessary to set up networks for the dissemination of a road safety culture, i.e. latest developments in the fields of accidents, measures, programmes, communication tools, etc. ([43] OECD, 1998: 197-9).

7.9 Adonis

The Project Adonis is the Analysis and Development Of New Insight into Substitution of short car trips by cycling and walking.
Task 4 consisted of setting up recommendations based on the results from the three above tasks:
Proposals to encourage walking:

- Walking - Ensure that different amenities can easily be reached by foot; provide and maintain adequate lighting in public areas; improve home delivery services; introduce traffic calming in areas with mixed traffic; and increase the number of car-free areas.
- Proposals to increase cyclist and pedestrian safety:
- Parking restrictions - ban parking near cross-roads; enforce parking restriction on pavement
- Light signals - introduce green arrows for turning cars and separate cyclist signals; stop use of flashing lights.
- Cycle paths and cycle lanes - separation of road users through the use of specially painted bicycle lanes or bicycle lanes and carriage way at different levels.
- Speed controls - humps, chicanes and enforcement.
- Bus stop and trams - move bus stops to intersections with high visibility; introduce more rules for tramways.
- Facilities in intersections - light signals instead of "give way lines"; recessed stop lines. Maintenance of road surface; smooth road surface.
- Conspicuousness - bicycle lamps and reflective items.

Facilities must be:

- cost effective;
- safe (both road safety and social safety) or at least be safer than the present solution;
- part of an integrated transport plan for cycling and walking ([1] ADONIS).

Summarising

On the existential level there is, for so far, no information. Information that could be placed at this level is for example information to be retrieved from literature on land-use planning.
It is not possible to summarise all promising interventions in this section. There are several (European) projects (PROMISE, PROMPT, OECD, ADONIS) that went into depth. Results from these projects were extensively described in this chapter including their recommendations made.
The current classification in this chapter (existential, strategic, tactical and operational) could be replaced by a classification on stakeholder level. Stakeholders correspond with these levels more or less. The existential level corresponds with land use strategies by the government. On the operational level decisions are made by localities.
The guiding principle should be a universal design, namely designing economically for as many people as possible at once. First the land-use planning, than the design and than the design on the network level.

8 Assessment of potential pedestrian system output

In this chapter the potential pedestrian system output relevant for general stakeholder interests are assessed. The external effects can be assessed on various levels of scale: personae pedestrian, individual, groups, organisations & (local) stakeholders, community, society (region, country) and continent. 'What's in it for me' will probably be the leading argument.

8.1 Existential level

For the time being no information.

8.2 Strategic level

Encouraging walking is key to delivering sustainable transport solutions. Walking and cycling are the only transport modes that have positive externalities, i.e. their use has benefits for society. Walking reduces traffic; is good for health; lowers crime; revitalises town centres and improves air quality.

Health, environment, price
Measures that improve travel conditions for walking or cycling may lead to a switching to these modes from motor travel. This may lead to a reduced need for providing bus transport of children to and from school. Traffic noise and air pollution may also be reduced, if the transfer of trips to walking and cycling is sufficiently large to make a noticeable difference in the volume of motor travel. The relevant monetary valuation of an increase in the amount of walking and cycling is the change in consumers' surplus that results from the change in the amount of travel ([16] Elvik, 2000: 39).
Generalised costs of travel are assumed to drop from 15 to 12.5 NOK (Norwegian Crown):km for pedestrians and from 10 to 7.5 NOK:km for cyclists when a separate track is provided. This decline in the generalised costs of travel is assumed to induce a traffic increase of 20 pedestrians per day and 25 cyclists per day. It is further assumed that bus transport to school is no longer needed for 25 children. The costs of providing bus transport are about 3.40 NOK per child per km (Engebretsen and Hagen, 1996). It is assumed that short term absence from work is reduced from 5 to 4% of all working hours for 20 workers who take up walking and cycling as a form of physical exercise. The average annual wage of these workers is set at 250 000 NOK. The number of accidents is not expected to change (Elvik et al., 1997). All estimates of costs and benefits based on these assumptions refer to a 1-km road section ([16] Elvik, 2000: 42).

Walking has many benefits for an individual and for society. For an individual, walking helps provide a reasonable level of fitness through exercise and is an inexpensive form of travel. For society, pedestrian traffic is environmentally friendly and the presence of pedestrians helps vitalise urban streets ([25] Hunt & Evans, 1999).

8.3 Tactical level

For the time being no information.

8.4 Operational level

In the economic evaluation of walking schemes, benefits have traditionally been measured by valuing time savings and safety at road crossings. The measurement of time savings can be applied to evaluating new routes, short cuts or the phasing of pedestrians signals. Evaluating safety at road crossings involves measuring the cost of accidents and is an important element in demonstrating the need for safe crossings. However, assessing time saving and safety alone does not capture the wide ranging benefits that walking projects offer. There are a wide range of other benefits that need to be quantified and assessed in order to demonstrate value for money in the same way as can be determined for hard modes ([22] Heuman et al., 2005: 1). Other benefits: accessibility, local economy, air quality, physical fitness, security.
Even though the benefits of walking (accessibility, local economy, time savings, quality, safety, air quality, physical fitness, security) are widely known, there is no established way to measure the extent to which economic returns exceed (or fail to meet) economic costs for the majority of these benefits. As a result, there has been interest in quantification and valuation of a wider range of benefits. … The DfT guidelines will encourage walking projects to conduct evaluations and better enable 'soft' modes to compete for limited resources. However, even with quantification of physical fitness and environmental benefits, many schemes will still be unable to demonstrate the wide ranging benefits that they offer. The only way for walking projects to affect physical fitness or health is to switch people from other modes to walking or encourage them to make new trips on foot. Expenditure on walking does both, but we do not yet understand the effect well enough to measure it. … The bulk of expenditure that does not relate to safety, new users or economic benefits, is spent on improving the quality of the walking experience ([22] Heuman et al., 2005: 2).

Walkability improvements can substitute directly for automobile trips. Walking improvements also support Public Transit and Ridesharing ([63] VTPI, 2008).

Nonmotorized transportation provides a number of benefits and costs.

- mobility benefits. Improved nonmotorized transport conditions increase travel choice and mobility, which particularly benefits non-drivers.
- TDM Benefits. Shifts from driving to walking can reduce congestion, road and parking facility costs, consumer costs, and pollution emissions (Litman, 1999).
- Safety and health benefits. Although nonmotorized modes have relatively high per mile casualty rate, this is offset by reduced risk to other road users, and by the fact that pedestrians and cyclists tend to travel less overall than motorists. International research suggests that shifts to nonmotorized transport result in overall increases in road safety. … Walking provides significant aerobic fitness health and fitness benefits.
- Liveability. Streets that are attractive, safe and suitable for walking are a key factor in community liveability.
- recreation benefits. Many people enjoy walking and the healthy exercise it provides.

- economic development. In several case studies, improving walking conditions in a community significantly increased retail sales and property values (LGC, 2001)
- costs. Costs are generally associated with program expenses and facility improvements ([63] VTPI, 2008).

Since nearly everybody walks, walkability improvements can benefit nearly everybody, although some people benefit more than others from a particular policy or project. Walkability improvements in general, and Universal Design improvements in particular, are particularly important for providing basis access and insuring opportunity who are transportation disadvantaged. Grayling et al. (2001) show that pedestrian safety improvements are particularly beneficial to economically and socially disadvantaged communities ([63] VTPI, 2008). In this case it is important who benefits from certain measures.
Nonmotorized transportation improvements are particularly important in areas with high levels of walking and cycling, higher-density commercial and residential areas, and resort areas. Universal Design improvements are particularly important in areas where people with disabilities frequently travel ([63] VTPI, 2008).

Safety
Interventions to improve the safety of older pedestrians have been shown to substantially reduce traffic-related deaths and increase the independence and wellbeing of the urban elderly. Implementation of these interventions, however, is not widespread. With the aging of the US population, further attention must be paid to this important public health problem ([28] Langlois et al., 1997: 396). Reducing deaths of pedestrians reduces costs of hospital and other costs.
Conflicts between pedestrians and vehicles can be reduced through physical separation, but this can be expensive and difficult to implement ([52] Retting et al., 1996: 28). When measures are very expensive it is possible that they will not be implemented.
The third example refers to the provision of traffic signals at a pedestrian crossing. It is assumed that daily traffic volume is 15 000 motor vehicles and 2000 pedestrians crossing the road. Providing traffic signals is assumed to impose a mean delay of 4 s per pedestrian and 2 s per motor vehicle (Hunt, 1990). The number of accidents is assumed to decline by 12% for pedestrian accidents and 2% for motor vehicle accidents (Elvik et al., 1997). According to a study by Schioldborg (1979), pedestrians believe that traffic signals reduce the number of accidents by 80%. In the present context, this is interpreted as the percentage reduction in the costs of insecurity that pedestrians experience when traffic signals are provided ([16] Elvik, 2000: 43-4). Fewer accidents mean fewer costs.
The hospital costs are also high for pedestrians injured in single accidents ([20] Gunnarsson (ed.), 2001: 11).

Skills
When pedestrians have more skills then the costs for the society to provide for the groups (blind, wheelchair etc.) are less.
Although the use of markings and signs prompting pedestrians to look for turning vehicles has been shown to be effective in reducing conflicts and may be warranted and appropriate at certain intersections, the wide-scale implementation of these prompts would prove costly. A more economical way to increase pedestrians' observing behaviour would be to incorporate the prompt as part of the pedestrian signal. Modifying existing signals would require adding a third pedestrian signal head. A more cost-effective method would be to incorporate an unambiguous

prompt as part of the pedestrian signal head display. One way to accomplish this would be to employ a light-emitting-diode (LED) pedestrian signal head and add animated eyes that scan from side to side at the start of the WALK indication. This study was designed to evaluate the use of such a display ([24] Van Houten et al., 1999: 30).
The introduction of either painted or sign prompts alone increased the percentage of pedestrians looking for turning vehicles. The introduction of a second prompt led to further improvements in the percentage of pedestrians looking for vehicles. Introduction of both prompts together led to a large increase in the percentage of pedestrians looking for vehicles similar in magnitude to that achieved by sign and paint at the other two intersections. Increases in checking for vehicles during the experimental period were generally associated with reductions in conflicts at all sites. It is noteworthy that Lord reported a high correlation between the type of conflict recorded in this research and crashes related to turning vehicles. Although the research was conducted at intersections with traffic signals, these relatively inexpensive signs and markings could be installed at pedestrian crossing locations without signals ([52] Retting et al., 1996: 34).
The forgiving nature of road users can help less skilled road users. This will lead to less severe consequences of mistakes. Especially in terms of deaths and hospital wounded road users ([58] SWOV, 2007b: 4).

Drunk pedestrians
There is a general consensus among experts that the public is not aware of the problem of alcohol impaired pedestrians despite the high costs such incidents place on society. Pedestrian injuries and deaths cost society, in terms of lost productivity and direct health care costs. There are also costs to the driver involved, including increased insurance rates, lost productivity and mental anguish (Shapiro 1993: 103). People who serve alcohol and who routinely have contact with drinkers, such as convenience-store owners, face potential liability suits. Insurance does not cover the punitive damages which are often assigned in cases involving drunk pedestrians (Shapiro 1993: 103 in: [40] Miles-Doan, 1996: 30).

Sidewalks
When pedestrians fall caused to bad maintenance of sidewalks this can lead to high claims for damages. Many sidewalks are not well maintained and annually 70.000 people seek medical help after falling on the sidewalk. Because of this and of the fact that people are more assertive the amount of claims for damages can increase ([36] Methorst, 2003a: 9).

8.5 In general

The number of hospital days per accident is considerably higher for pedestrians than for other road users. The average hospital visits for a car driver injured in a traffic accident in Sweden (in 1991) was 10 days, for an injured pedestrian 23 days. However, one must keep in mind that elderly people are more vulnerable than younger people ([20] Gunnarsson (ed.), 2001: 10).

Over the course of forty years, appraisal systems have been developed that measure the costs and benefits of road and public transport schemes. These scheme appraisals include monetary valuations of improvements to quality (such as comfort, reliability and security). However, for walking, there is no equivalent way of evaluating quality improvements. This is despite the fact that the majority of expenditure on walking schemes is focussed on improving quality ([10] Buchanan, 2005: i).

For the 2003 annual local transport funding bid for London's Strategic Walks, Colin Buchanan developed an approach to quantifying and valuing the benefits of pedestrian improvements, including quantitative measures of safety, health and quality. This report builds on that approach by using stated preference research as a mean to assess willingness to pay for quality improvements. This is an established approach to determining quality benefits. … The surveys assessed willingness to pay at two locations on the Strategic Walks (in London) ([10] Buchanan, 2005: i). The findings of this research have been incorporated into WAVES, a model developed by Colin Buchanan to place money values on quality benefits for walkways. WAVES can determine the economic returns of investments in walking for urban, fringe and rural areas around the country. It assesses investment in walkways based on user numbers, proposed improvements and the characteristics of the locations ([22] Heuman et al., 2005: 12). An example of how it can be carried out is in the paper.

Walking and walkability provide a variety of benefits, including basic mobility, consumer cost savings, cost savings (reduced external costs), efficient land use, community liveability, improved fitness and public health, economic development, and support for equity objectives ([32] Litman, 2007: 1).

In many situations the best way to improve urban transport is to improve walking and cycling conditions and restrict automobile travel. Although this does not increase travel speeds it improves the overall convenience, comfort and affordability of access to destinations ([32] Litman, 2007: 3). The benefits for pedestrians are the improved convenience, comfort and affordability.

'Transportation planners have standard ways to evaluate motor vehicle traffic conditions and improvements. For example, computer models such as the Highway Design and Maintenance Model (World Bank) and MicroBENCOST (TTI, 1997) calculate the monetized (measured in monetary units) value of vehicle operating cost savings, safety benefits and travel time savings from roadway improvements. These economic evaluation models generally assume that society is better off if a person spends 5 minutes driving for an errand than 10 minutes walking or cycling, since it applies an equal or greater cost value to nonmotorized trips than motorized trips, only considers vehicle operating costs (vehicle ownership costs, and external impacts such as congestion and parking costs are ignored), and no value is assigned to the health and enjoyment benefits of nonmotorized travel. Such assumptions tend to skew countless planning decisions toward motorized travel at the expense of non-motorized travel' ([32] Litman, 2007: 4-5).
… These practices help justify roadway projects. Walkability is not as easily quantified and so tends to be undervalued in planning and economic evaluation ([32] Litman, 2007: 5).
However, travel surveys can collect more detailed information on nonmotorized travel (for example, asking respondents to identify any walking trip on public right-of-way), and in recent years new techniques have been developed to better evaluate walkability ("Evaluating Nonmotorized Transport", VTPI, 2004 in: [32] Litman, 2007: 6).
Conventional planning tends to ignore or undervalues benefits such as fitness and public health benefits of active transportation, enjoyment of walking and cycling, and improved mobility options for non-drivers. The role that nonmotorized travel plays in supporting public transit and rideshare travel is often overlooked. Many transportation economic evaluation models even

ignore benefits such as reduced congestion, parking cost savings and consumer cost savings that result when travel shifts from driving to nonmotorized modes.

Table 7 summarizes the categories of economic benefits that should be considered when evaluating walking.

Table 7 – Walkability Economic Impacts

Name	Description	Measuring Techniques
Accessibility	Degree that walking provides mobility options, particularly for people who are transportation disadvantaged.	Travel modelling, analysis of travel options.
Consumer cost savings	Degree to which walking provides consumer transportation cost savings.	Consumer expenditure surveys
Public cost savings (reduced external costs)	Degree that walking substitutes for vehicle travel and reduces negative impacts.	Determine to what degree walking reduces motor vehicle travel, and the economic savings that result.
Efficient land use	Degree that walking helps reduce the amount of land used for roadway and parking facilities, and helps create more accessible, clustered land use.	Identify the full economic, social and environmental benefits of more pedestrian-oriented land use.
Liveability	Degree that walking improves the local environment.	Property values, business activities, consumer preference surveys.
Public fitness and health	Degree that walking provides physical exercise to people who are otherwise sedentary.	Travel and health surveys to determine the number of people who benefit from walking exercise.
Economic development	Degree to which walking makes commercial areas more attractive and shifts consumer expenditures to goods that provide more regional economic activity and employment.	Market surveys and property assessments. Input-output table analysis.
Equity	Degree that walkability helps achieve various equity objectives.	Various indicators of horizontal and vertical equity.

This table summarizes various categories of impacts to consider when evaluating walking ([32] Litman, 2007: 15).

Accessibility can be evaluated using resident surveys, field surveys an Geographic Information Systems (GIS) to determine the portion of important destinations (medical services, shops, schools, jobs, government offices, etc.) that can be conveniently reached by walking or walk-transit-trips, particularly by disadvantaged populations ([32] Litman, 2007: 7).

Table 4 – Land Use Benefits of Improved Walkability

Economic	**Social**	**Environmental**
Improved accessibility, particularly for non-drivers. Reduced transportation costs. Increased parking efficiency (parking facilities can serve more destinations). Can increase local business activity and employment. Support for transit and other alternative modes. Special support for some businesses, such as walking tourism. Health cost savings from improved exercise.	Improved accessibility for people who are transport disadvantaged. Reduced external transportation costs (crash risk, pollution, etc.). Increased neighbourhood interaction and community cohesion. Improved opportunities to preserve cultural resources (e.g., historic buildings). Increased exercise.	Reduced land needed for roads and parking facilities. Openspace preservation. Reduced energy consumption and pollution emissions. Improved aesthetics. Reduced water pollution. Reduced "heat island" effects.

This table summarizes various benefits from a more walkable community ([32] Litman, 2007: 10).

Community liveability refers to the environmental and social quality of an area as perceived by residents, employees and visitors (Weissman and Corbett, 1992; "Livability", VTPI, 2004). This includes safety and health (traffic safety, personal security, public health), local environmental quality (cleanliness, noise, dust air quality, water quality), community cohesion (neighbourliness, respect, community identity), opportunities for recreation and entertainment, aesthetics, and the existence of unique cultural and environmental resources (e.g., historic structures, mature trees, traditional architectural styles) ([32] Litman, 2007: 11).
… To the degree that improved walkability increases community cohesion, it may help reduce crime and other social problems in an area (Litman, 2002 in: [32] Litman, 2007: 11).

More comprehensive benefit-cost analysis requires better techniques to measure and predict travel impacts of improved walkability, and to evaluate the full economic impacts that result, including indirect and nonmarket impacts that are not usually quantified in transport planning such as environmental, economic development and equity impacts ([32] Litman, 2007: 19).

These effects can be expected rather than it already has been proved to be real effects. The system effects expected from the types of interventions promoted by PROMPT can expect to increase walking in cities, which in turn will, among other things:

- promote other non-motorized transport modes and the use of public transport instead of private car,
- abate harmful impacts of transport on the environment,
- improve the accessibility of public spaces,
- improve the health of citizens,
- improve their equality and
- decrease costs of road investments, building repair, pollution abatement, accidents, health care, etc ([50] PROMPT).

Summarising

There are several system effects walking can have. Examples are that walking reduces traffic (and traffic noise), is good for health, lowers crime, revitalises town centres, improves air quality, measures can reduce deaths or injuries. Other effects can be found in the tables shown in this chapter.
It is hard to quantify all the effects walking can have. Buchanan developed an approach to quantify and value the benefits of pedestrians improvements.

No information about the existential and tactical level was found in the literature that was studied. . A classification of information in terms of macro, meso (for examples zoning schemes) and micro level could result in better spread across those categories than the spread as shown above.

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