COST 358 Pedestrians' Quality Needs

Functional Needs

PQN Final Report - Part B1: Documentation

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PQN project - Working Group 1 Functional Needs

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PEDESTRIAN QUALITY NEEDS
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Colophon:		
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1. Introduction

Within the COST 358 Pedestrians' Quality Needs COST project, the Working Group 1 focussed on collecting the available knowledge on the physical needs of pedestrians: visible and objective behaviour, information on use of public space, ergonomics of the physical and social environment, and the transport modalities.

The study work concentrated on reviewing literature, gathering available statistics and re-interpretation of available research data and internal working group discussions (8 meetings across the four yours lifetime of the project). Apart from the Country Report questionnaire, no original surveys were undertaken. Whenever possible the work resulted in recommendations regarding standards for land use, public spaces, information, legislation and transport modes, allowing for substantially different situations in the participating countries and sub-regions.

Initially the work was organised through provisional working units according to topics that were identified with help of the Conceptual Framework. In the first stage of the project material was collected. This served as input for preparing the working group report, which in the end resulted in a 16 chapter working group book, that can be seen as an impetus to a handbook on the pedestrian issue.

2. Background and objectives Working Group 1 Functional Needs

Working Group 1 Functional Needs covers one of the four research perspectives taken in the PQN project: the functional perspective, being the 'rational' perspective, dealing with features of the pedestrian issue that can be measured. The group focussed on the physical and observable ('objective') needs of pedestrians, visible and objective behaviour and 'technical' ergonomics with regard to the physical and social environment and the transport modalities. The research explored the presence and the behaviour of pedestrians in public space, and the relationship and influence of mobility, safety, physical health and exclusion.

The study work is based on a number of key research questions, which were formulated at the start of the work process. The study work concentrated on reviewing literature, gathering available statistics and re-interpretation of available research data. Apart from the Country Report questionnaire, no original surveys were carried out. Whenever possible the work resulted in recommendations regarding standards for land use, public spaces, information, legislation and transport modes, allowing for the great variety of situations across the participating countries and sub-regions.

The report covers the following themes:

- Papers on data availability and conclusions from statistical sources (4 papers)
- Papers on pedestrian needs, abilities and opportunities on the Lifestyle and Strategic activity levels (3 papers)
- Paper on the pedestrians' tactical activity level decision making (1 paper)
- Papers on the pedestrian's needs, abilities and opportunities on the operational activity level (3 papers)
- Papers on interventions that can improve walking and sojourning conditions (3 papers)
- A paper on conclusions drawn from the Working Group 1 results.

3. Qualitative approach to assessment of pedestrian environment

Ms. Dell'Asin concludes that in the past, European cities have always paid attention to pedestrians' needs. Traditionally walking was the prevailing means of transport. However, during the last century, car driving has been granted increasing priority in investment programs, and the rising urban car dependency has negatively affected taking care of pedestrians quality needs (PQN). Because of these problems, European cities will now have to steer away from car-oriented policies, aiming at a more sustainable design and transport planning, as well as an effective mobility management. In general, countries appear to be on the right path, and there are several examples of pedestrian-friendly cities. However, more needs to be done and in the European context there are too many disparities between countries performances.
Dell'Asin presents the PQN matrix comprising a qualitative approach to assessing pedestrian environment. Pedestrians' quality needs are translated into five basic requirements: connectivity, conspicuity[1], comfort, convenience and conviviality. This framework only takes into account the connection between pedestrians' needs and the physical environment, whilst neglecting the other three components of the system, i.e. person, vehicle and organisation. A practical application is also provided, through the analysis of twenty pedestrian-friendly cities in the countries taking part in COST Action 358. This analysis aims at developing a comprehensive comparison among these cities, stressing their differences and similarities.
This article is based on the key findings achieved from the Short-Term Scientific Mission (STSM) that took place in February and March 2008 at DVS - Centre for Transport and Navigation now based in Delft (The Netherlands).

4. Data on pedestrian mobility and safety

This paper by Cabello, Sanchez, Martin, Belén Cabello, De Goede, Van der Horst, Conde and Romay is devoted to currently available *data sets on mobility and safety of pedestrians*.

Adequate information is needed on the actual conditions of pedestrians´ mobility and safety. Together with better information on perceived difficulties and insight in desires can help to detect what basic needs must be met, so that even the most vulnerable persons can easily

[1] The quality of being **conspicuous**; obviousness (www.thefreedictionary.com/conspicuity)

choose to walk more frequently. Urban space must be accessible for all citizens, independently of their age and different characteristics.

Until now, knowledge of the walking conditions and on the safety of those road users is incomplete and lacking in quality. The walkability of the pedestrians´ environment will only be improved if policy makers have correct and detailed information on the actual quality needs of pedestrians in general and on the specific needs of vulnerable groups of these road users.

There is no universal European survey standard for mobility and safety data on walking and sojourning. This has several consequences. The most important ones are:

- Sets of data are only roughly comparable. Definition of words (trip, journey, period of time considered) can change between countries. The way which the data is gathered can also be improved and made consistent: by phone, by mail...
- Information is sparse on several countries web pages, some of them written only in the national language. Most of these national level mobility surveys have English translation, but some of them translate only the main figures. So, even when the information is available, it is hard to find it in short time or just by clicking on few web pages.
- In addition to national level information, there are a huge number of local or regional web pages with mobility data. Web pages containing surveys with non-standardised data provided by European funded research projects are placed everywhere. These kinds of data are usually tailored to the project or to the local problem, and therefore hard to compare with other situations.
- Surveys about short distance mobility are mainly focused on cars or public transport. Presumably the underlying interest is the usability of these figures by local governments to collect information about its own networks of public transport. For long distances it is almost always assumed that cars or public transport are the only options.

5. Pedestrian risk and risk factors

The paper by Hakkert deals with analysis of the aspects related with the concept of *pedestrian risk and risk factors.* His chapter sets out with a definition of the three central terms used - accidents, exposure and risk. The conclusion reached is that there are general definitions of exposure and of risk as used in the health prevention and risk analysis fields but that in the road safety practice these terms should be defined within the context of the issue studied. In the context of this project, exposure is meant as exposure to risk. The measure of exposure is generally defined as some form of the amount of travel, either by vehicle or on foot. Risk is used to mean the probability of an accident occurring, weighted in some way by the severity of the accident's outcome. In many cases it would be better, and more neutral, to refer to rates and not to risks.

Very little is known quantitatively about walking. The amount of walking, including short trips and trips which are part of a motorised journey are generally not recorded. Another related issue is that little is known about the number of road crossings by pedestrians, an indicator which could be used to calculate the crossing risk.

For each application, the correct exposure measure should be used. This is sometimes made impossible because the required information is not available, or has to be collected at great cost. Generally, the more aggregate the exposure measure, more indirect variables are introduced which casts shadows over the resulting risk calculations.

6. Pedestrian safety data

This paper by Véronique Feypell – De la Beaumelle, Eleonora Papadimitriou and Marie-Axelle Granié (courtesy OECD / International Transport Forum – Working Group Pedestrian Safety, Urban Space and Health) provides an assessment of the magnitude of pedestrian safety in urban spaces. It addresses both non traffic accidents (i.e. a pedestrian falling) and traffic accidents (a pedestrian hit by a vehicle), thus giving a more complete image of accidents that happen to pedestrians.

The paper starts with describing relevant definitions of pedestrian accidents. Next the issue of underreporting is discussed.

The third section highlights the fact that non traffic accidents constitute an important part of the safety problem of pedestrian, which is often not reported and not well known. Only a very limited number of countries have gathered data on this issue. It is found that, compared to traffic accidents there are 3 to 9 times as many pedestrians severely injured (admitted to hospital) in falls. Around 80% of pedestrian severe injuries are due to falling and, since the impact force when falling is lower than the impact of a moving vehicle, the count for pedestrian fatalities is substantially lower: 1 of every 3 pedestrian fatalities were due to falling.
Most (more than 85%) of the accidents happen in urban areas on sidewalks, roadways and cycle ways.
The vast majority of victims are children (0 – 14 years) or elderly. The majority of severely injured the victims are elderly. Because of ageing of the population, it can be expected that this constitutes a growing problem.
In countries with marked winter conditions, ice and snow are the major factor in falls; in warmer countries unevenness, potholes and rutting can be expected to be the major causal factor for falls. Maintenance (slippery leaves, rubbish on the street) is a third factor.
With regard to costs of pedestrian falls very little data exist. An indicative Dutch study shows that 16% of all societal costs of travel accidents are related to pedestrian falls, amounting to 1.4 billion Euros of the total of 8.9 billion Euros of travel accident costs (incl. Falls) in the country.

The fourth section focuses on collision of pedestrians with motorised traffic and describes various accident scenarios. The section starts with a macroscopic pedestrian traffic safety analysis in OECD/ITF countries. Internationally 17.8% of all traffic accident fatalities are pedestrians. Fatality rates vary very much. In the safest countries the number of fatalities is as low as 3.8 fatality per 100,000 inhabitants, while in un-safe countries the score higher than 14 per 100.000 inhabitants (i.e. Poland). The number of fatalities shows a downward trend.
Contrary to other road users, most of the pedestrian traffic fatalities are due to accidents in urban areas. Internationally some 35% of all pedestrian fatalities had their accident in a rural situation.
Like in falls, there is an age relation. The average risk amongst the elderly is 25 fatalities per million inhabitants. For children the average risk is 5 fatalities per million in habitants. There is however a huge spread in scores per country.
The car is the dominant opponent in pedestrian traffic accidents, but the involvement per billion vehicle kilometres shows a different picture. Motorcycles and buses are over-represented. Speed is the most important causation factor.
In general 4 accident types (scenarios) are distinguished: accidents during crossing (more than 70% of the pedestrian traffic accidents), accident on pavement, out of crossing, accidents where pedestrians are collateral damage and ‘particular context.

7. Principles for simplification of pedestrian tasks

This section by Auserer, Risser, Kaufmann, Barker, Johansson and Leden provide an overview of task pedestrians have to perform and of principles how tasks can be simplified.

Walking is the most natural and simplest way of getting around but, due to the ever increasing complexity of the traffic system, it has become a mode in which a variety of tasks have to be performed. The starting point of this chapter is theoretical models.

Theoretical models of task performance (Michon's hierarchical model or Rasmussen's knowledge and experience based model) are one possibility how to describe the tasks of pedestrians on various levels. What operation pedestrians have to perform is affected by various elements like: who is the person performing the task (target group: children, the elderly etc.) and what is the reason for walking (trip purpose: leisure time trip, working trip), among other things. In addition the task performance of pedestrians can be viewed from two temporal aspects: tasks before the actual trip and tasks while the trip is performed. Pre-trip tasks are mainly carried out on a strategic level and refer to decisions on the equipment (like protective clothing, shoes, umbrella) and on the route itself. Several tools support pedestrians on planning their walking trip like printed maps, internet, route-planners, navigation systems etc. These tools, however, often lack information as they were not developed for pedestrians, but for car drivers. For example shortcuts for pedestrians e.g. through an apartment complex are hardly mapped.

Tasks during the actual walking trip are of a tactical pro-active or automated operational character. During the trip one has to choose the route, interact with other road users, cross roads etc. For choosing one's route, guidance systems support pedestrians to find their way. These guidance systems are not always adapted to the needs of different target groups of pedestrians. For example mobility barriers like stairs are hardly ever indicated. A safe, direct penetrable/cross-linked, well arranged, attractive and usable pedestrian network guarantees a smooth walking, without having problems to carry out various reactive tasks. Besides, there are several infrastructural measures which can be implemented to "simplify" the task of crossing and increase the traffic safety and sojourn quality for pedestrians, at the same time like enlargement of sidewalks at crossings, traffic islands or lifting of the whole crossing.

One important aspect with respect to planning for pedestrian is to focus on children to ensure the walking trip is as simple and safe as possible. Low traffic speeds, visibility, light traffic flow, only a few or no lorries, are only some aspects which should be considered when planning for pedestrians and especially for children.

8. Factors that determine strategic walking decision

Insight in the individual physical health and competence factors and mechanisms which determine the outcome of strategic decisions with regard to walking is provided in the paper by Basbas, Konstantinidou and Moreno. The analysis covers "objective" factors and mechanisms which determine the pedestrians' travel and/or sojourn motives such as health factors (physical ability, mental health benefits of daily walking, etc).

The pedestrians' needs or problems and infrastructure characteristics for pedestrians and pedestrians with disabilities as well, are presented. Special emphasis is usually given to the safety and accessibility issues related to the movement of pedestrians. The results of various questionnaire based surveys, aimed at the identification of the needs of the pedestrians and improvements-deteriorations of the situation are also presented in this chapter.

Finally, an attempt is made to understand the relationship between travel / sojourn decisions and social context, land use and physical environmental characteristics and transport system characteristics in order to find all factors which can influence peoples' walking decisions.

The results of the current chapter will help planners in the future to design a better walking environment. The aspects covered within the framework of this chapter need further research in order to obtain robust conclusions.

9. ITS and walking

The paper by Monterde-i-Bort, Johansson, Leden and Basbas is devoted to Intelligent Transportation Systems (ITS) and Walking, concretely to substantiate to what extent Information Technologies can improve the pedestrian's mobility options and safety.

Information technology (IT) was defined by the Information Technology Association of America (ITAA) as: "the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware." IT deals with the use of electronic computers and computer software to convert, store, protect, process, transmit, and securely retrieve information.

Information and communication technologies can help to improve their efficiency and safety of transportation, transportation infrastructure and vehicles. Such dedicated applications can deliver Intelligent Transportation Systems (ITS).

With the evolution of the modern societies, the Intelligent Transportation Systems (ITS) have evolved from the motorised transport to all kinds of transport and mobility, including recently the pedestrian group.

This chapter analyses and compiles the various ways that Information Technologies (IT) can support pedestrians. The most important developments are described with links to their websites, where the reader can obtain more information. Also analysed are the different applications and potentials of the Intelligent Transportation Systems (ITS) and Information Technologies for improving the mobility and safety of pedestrians in urban spaces. In total 11 functional types of applications are identified and documented:

1. for getting contact and/or being localised,
2. for guidance (leading/navigating),
3. for alerting or informing of a danger,
4. for adapting the environment to pedestrian conditions,
5. for promoting confidence and/or security,
6. for counting and controlling flows,
7. for simulating (flows, accidents, evaluating consequences,..),
8. for compensating for handicaps of special collectives,
9. for redesigning (vehicles, spaces, urban furniture,…) to reduce the accident damages,
10. for checking and measuring the efficacy of developed solutions, and
11. for encouraging going around and walking.

Examples in each category are given, among the different projects and experiences carried on across the world.

Finally, a section is devoted to children as a special case of pedestrians:

Telematics and other types of Intelligent Transportation Systems, ITS, such as Intelligent Route Guidance Systems (for pedestrians), Advanced Driver Assistance Systems (ADAS), Intelligent pedestrian crossings and Intelligent Speed Adaption (ISA) seem to be needed to satisfy Child Pedestrian and drivers' Quality needs. Intelligent signal-controlled crossings for pedestrians should automatically detect pedestrians, as well as prioritising and adapting green phases; especially child pedestrians need these features.

Probably, Intelligent Speed Adaption on motor vehicles is the most efficient measure to achieve a safe and independent freedom of movement for children, which should be granted according to the UN 'Children's Charter', specifically the Convention on Children's Rights. Vehicle speeds should be 15-20 km/h or less wherever children 7-12 years old (regularly) cross streets. For older children the same principles apply as for adult unprotected road users: they should not cross at locations where vehicle speeds exceed 30 km/h. Pre-school children should not encounter cars in their playing and walking areas. However, if a pedestrian or bicyclist is hit by a truck or bus, the fatality risk is high at any speed. Therefore, also ITS measures like ADAS, are needed for children to see and be seen and measures are needed to improve orientation and create clarity.

10. Parameters route choice in walkable networks

The paper by Czogalla concerns an analysis to identify parameters determining route choice of pedestrians in walkable networks.

As a scientific project result, a model of the pedestrian's route choice decision was developed. This relates to the tactical level of a trip. A pedestrian's trip is considered as a non-stop route from a fixed starting point to a given destination point within a network accessible by pedestrians that includes alternative ways.

With respect to trip purpose and spatial relations the tactical level differs from the superior strategic level and subordinated operational level. At the strategic level the purpose, the origin and destination, the choices for traffic mode and time of departure are being decided before the trip starts. Especially at the tactical level, decisions are being made for the actual route in consideration of alternative ways of the walkable network during the trip.

Consistent with one of basic human natures: maximisation of utility, the decision making process is modelled by minimisation of walking costs in an attributed network. It takes into account both the network related quality and individual related factors. For this purpose the concept of a pedestrian quality attribute and its determination by physically assessable factors was developed. These network related quality factors, such as safety, attractiveness and comfort, are combined with individual soft factors such as social interaction or personal moods. Further individual factors, such as time constraints and physical abilities are incorporated in the model as they influence the weight of attributes used in the process of maximising the personal utility of the human pedestrian.

In result of the evaluation of considered factors, the walkability attribute determines the measure of virtual distance of network links. The virtual distance is used for minimisation of walking costs by a least cost routing algorithm serving as the basis for route choice. In order to justify the application of the model, it is presumed that the walking individual acquired his knowledge of network quality by prior walks in the network. Provided this essential precondition is fulfilled, it can be assumed that the directions given by the conventional route search algorithm follow closely those of the human mental decision making during the live walk.

Hence, the described approach supports a better understanding of influencing factors and mechanisms of the human mental decision making process as it is important for the analysis of pedestrian quality needs.

11. Functional abilities

The paper by Vukmirovic presents the main results and conclusions related to the research of functional abilities of humans and identifications of specific groups of pedestrians.

Abilities are individual characteristics which enable someone to perform tasks up to a certain level. The abilities can be divided into four groups: physical, psychomotor, sensory and cognitive abilities. Physical abilities are those individual skills that include strength, endurance, flexibility, balance and coordination. Psychomotor abilities are skills that affect the ability to manipulate and control objects. Sensory abilities are abilities that affect the visual, sound and speech perception. Cognitive abilities are the abilities that affect the acquisition and use of knowledge during solving certain problems. Having in mind the identified groups of abilities, there were analyzed the characteristics and abilities of pedestrians that influence pedestrian movement, and segments and elements of pedestrian traffic and infrastructure on which it can be reflected.

Following the identification of basic kinds of abilities that are necessary for walking, the physical environment, social environment and transportation access, as preconditions for the safe mobility of pedestrians are considered. Those preconditions affect the decisions on all three strategic levels (operational, tactical and strategic) regarding the movement of a pedestrian. Moreover, the listed preconditions do not act independently, but as a system.

Based on abilities and characteristics, specific groups of pedestrians and their general characteristics are identified and described (children, adults, elderly and persons with disabilities). The logic of classification is established on principle that the first grouping is based on the main characteristics of pedestrians. Next substantiation and analysis follows to document preconditions (physical environment, social environment and transportation access) for the safe mobility of pedestrians that belong to the defined category. Besides the selected main groups, some groups that are classified as “others” are also mentioned in this article, but these are not dealt with in detail. This needs to be done in a separate study.

The consequences of limitations and functional impairments of different groups of pedestrians are explored for the three levels of decision making (operational, tactical and strategic). Clearly the identified groups show a specific behaviour related to their abilities, and it appears that on each decision level there are also great differences between the groups. In this context we conclude that it is necessary to ensure barrier free environments (physical, social, transportation, etc.) in which people can move and sojourn freely and independently, without being restricted by limited abilities.

With regard to walking and sojourning in public space the main aim should be to make sure that walking becomes a choice for all (C4A). In this respect it is vital that policy makers and designers have knowledge about behavioural abilities of the different groups of pedestrians that need to be supported. They should be aware of the consequences of the different characteristics of these individuals and deal with them properly.

12. The safety of pedestrian crossing

The paper by De Goede, Groenewoud and Van der Horst is devoted to *the human abilities and user groups related to crossing behaviour and crossing facilities.*

More than half of all severe traffic accidents in which pedestrians or cyclists are involved occur during road crossing. In this chapter insights, based on previous studies and literature, concerning requirements for safe and comfortable crossing facilities are discussed.

In order to develop notions of needs, abilities and motives, different pedestrian groups with similar physical and cognitive characteristics have to be defined. Research has shown that children under 11 and elderly above 75 years old are the most vulnerable pedestrian groups. Based on the development of cognitive capacities, such as attention, inhibition, planning and risk perception, in children a subdivision of four different age groups is proposed: children from 0 to 4 years old, children from 5 to 7 years old, children from 8 to 12 years old and children from 13 to 17 years old. Besides children, also people aged over 65 represent a vulnerable group of pedestrians, due to physical as well as functional constraints. In general elderly have a reduced physical fitness and -resistance, lower workload capacity and a reduced peripheral field of vision. Another group of pedestrians that deserve special attention are handicapped road users, either being physically or cognitively disabled. Whereas healthy adults are the least vulnerable, suboptimal situations in environmental design, crossing facilities and specific traffic circumstances may still create conditions that exceed the limits of normal human functioning.

Irrespective of the specific pedestrian group, good walking conditions are required to have people at least consider the option of walking. With respect to road crossing, it is especially relevant whether a crossing facility is safe and inviting (Convivial), comprehensible (Conspicuous) and whether facilities are sufficient in number and quality (Convenient). Since crossing involves a complex set of actions, providing pedestrians with crossing facilities can reduce cognitive load. In general an unsignalised crossing is more dangerous than a crossing that is signalised with traffic lights. The presence of other crossing facilities, such as a median or a zebra can help to increase (feelings of) safety. Whether safety is actually increased by these measures, is dependent on many factors such as its location, its visibility and traffic density. Besides general requirements, specific pedestrian groups have distinct preferences and needs. For example, a green light period should be adapted to the walking speed of older people or physically disabled people in order to make them feel safer. For younger people a relative short green light period causes impatience and therefore a higher risk potential. Therefore, in designing facilities for pedestrians, it is valuable to investigate which people will probably be mostly present.

In the final part of this chapter, conflict patterns and measures to reduce conflicts and accident severity are discussed. The most important conflict partner of the pedestrian while crossing a road, is the car (65%). In the Netherlands 84% of all pedestrian traffic accidents with severe injuries occur within urban areas. Whereas in an absolute sense, most pedestrian crashes occur in daylight, crash rates are higher during the night, when controlled for exposure and vehicle flow. Measures to reduce conflicts can concern measures on the behavioural level (education, public campaigns) as well as changes in traffic rules (speed limits), infrastructural design (separation of road users differing in mass, speed and direction and vehicle design (pedestrian-friendly car fronts, side-underrun-protection)

Based on above findings it can be concluded that the development of safe and comfortable crossing facilities first of all requires insights in pedestrian needs and abilities. Moreover, the specific needs of specific groups of pedestrians have to be taken into account. The benefit of such an approach is two-fold. To start with, gaining insight in these aspects makes traffic-engineers more conscious of the necessity to systematically meet pedestrian needs in our traffic system, in order to develop a safe and convenient pedestrian environment. Secondly, it provides us with concrete knowledge on which factors at which locations have to be taken into account when designing crossing facilities.

13. Walking accessibility of public transport modes

Malasek analyses the *walking accessibility of public transport modes*. The main goal of the PQN project is to make walking more popular within the city, what can help to solve traffic problems on the streets overloaded by the car traffic. The most important task is to promote people to walk during the inevitable trips (to work, school, university, etc), which are usually made at least twice a day. As asking people to go on foot several kilometres, however, is unrealistic. Such longer journeys can be made by public transport, where walking covers a substantial part of the trip chain. People will choose to use public transport more often when the walking conditions are better. In this paper we concentrate on the method for measuring the attractiveness and accessibility of public transport stops.

The formula for counting the index of public transport stops attractiveness in particular location comprises the following factors: the rank value of public transport stop, walking distance and walking comfort. The importance of public transport stop depends mainly on transport mode, number of lines and it frequency. An average walking distance to the nearest public transport stop within the district can be short when the density of public transport routes is high and the land use is intensive. The walking comfort is described by detour and vertical alignment factors. Also traffic conditions (including the road safety), functional and environmental issues are taken into consideration.

The presented method is prepared for validation of walking comfort and public transport stops attractiveness and their accessibility. It can be an important tool for measuring living conditions in urban areas. It can be used by the local governments as well as citizens from local communities to measure and compare the level of walking comfort, transport services and living conditions in particular neighbourhood. The index of public transport stops attractiveness for pedestrians living in particular city area can be used by city planners and public transport providers for making city standards for different city zones, depending on density of population and work places.

14. Interventions to improve walking and sojourning

Von der Mühl and Hanocq picture general practical options regarding *the Interventions, strategies and policies that can improve the pedestrian situation.* The paper is based on the analysis of relevant elements from the country reports delivered in the frame of COST 358 (20 countries involved). It identifies domains where interventions, strategies and policies are undertaken (or should be), and when possible what sort of effects and improvements can be expected. It also tries to highlight specific situations and examples from the countries involved, in the different domains: planning and transport, road safety and traffic calming policies, research and publications, training and education of practitioners, impulse tools and programs, incentive actions towards users, lobbying and involving of actors.

Strategies and policies that can improve the pedestrians' situation cover a large range of domains and actors. European wide, at a first stage policies are more or less always focused on safety issues (pedestrian as a vulnerable user, road safety towards children and elder people) and reactive approach (problem oriented). Since beginning of 2000 some countries or big cities (such as London) began to develop more proactive and global policies, considering walking as part of sustainable transport and urban quality, also linked with health issues (walking as an everyday body exercise).

Urban development remains a major issue for making walking possible and public transport efficient. Awareness, developing knowledge, stimulating willingness among policymakers and practitioners are important points: walking is the most natural and the most applied way of moving, paradoxically for years the less known and considered one by the authorities, and skills on the issue are still widely missing. The growing interest in pedestrian issues has to be fed with research and publications, education and training, pilot projects, sensitizing actions involving professionals, policymakers and the population. As the safety issue remains an essential point, the image of walking and pedestrians has a large potential to evolve in a more positive way: walking as the core of mobility and pedestrian as a crucial ingredient of urbanity.

15. The design of the walking environment

Martincigh and Tonelli describe the *indicators and measures of the walking environment design*. After a brief introduction that puts the issue in the broader contest of functionality needs, this paper provides indications on how the stage of the design of the walking environment can be faced.

In the first section an account is given of essential indicators devised both for evaluating the actual urban situation and for guiding the choices to be made in the design of a pedestrian environment, meeting users' needs and expectations at the most. Then, after having explained the role of the indicators and the reason why it is worthwhile to make use of them, it reports how they are connected to the Common European Indicators related to urban sustainability, and in particular to sustainable mobility. The indicators are:

1. The amount of space devoted to pedestrian mobility, sojourning and social relations
2. The density of network of pedestrian paths
3. The amount of streets with 30 km/h or lower speed limit
4. The amount of parking areas
5. Accessibility to the public transport system.

Five of them have been selected since they seem to be the most appropriate to the matter at hand; they are related to the requirements/performances of accessibility, safety and use. The core of this part of the essay concerns the choice of the specific aspects the indicators have to govern and the description of the proposed ones, that points out briefly only their most important features, as the definition and the meaning, the main goal and the reference values for the assessment.

In the second section, from the design point of view, the chapter, at a project level, will deal with some measures devised for improving the walking environment as regards the accessibility and comfort requirements: the former has been chosen since it is the basic condition for enabling pedestrians to use the urban spaces, the latter has been chosen since it represents an ever-increasing exigency, consequent to urban pollution problems and to climatic changes. Also in this case, only some technical measures are outlined: as regards accessibility, they are related to some of the indicators previously described. It explains then the importance of space accessibility for performing the various activities and which are the most important measures to implement. Moreover it describes briefly each measure, pointing out its main aim, some technical specifications and a comment on its efficacy. This section closes with some notes on the main characteristics of the materials used for the construction, always referring to accessibility and comfort requirements.

Indicators and measures represent two subsequent steps of the design process; the two sections of the paper give insights on how these steps can be faced.

The results here reported come from the research that was made by the authors in various institutions, at different time. As consequence the proposed indicators and measures refer to requirements in some case different and therefore they are not always directly related.

16. Conclusion

A first orientation on policy practises regarding walking and sojourning delivers that, although car dependence has emerged, the issue still receives much attention, at least at the city level. It appears that nearly all cities have implemented measures to improve public spaces, networks and sites for the use by pedestrians. It is however obvious that even the good examples do not score on all key quality factors (connectivity, conspicuity, comfort, convenience and conviviality) at the same time.

One of the benefits of a systems approach is that it produces insights enabling researchers to actively check for completeness and validity of data sources. The systems approach provides a framework for looking at data from a wider perspective than commonly used. It was found that the availability and the quality of data on mobility and safety leave a lot to be desired. Mobility and accidents are seriously underreported; the accuracy and completeness is not always satisfactory; important aspects of walking and walking safety are not covered.

However, it also proved to be possible to get basic insight in the real magnitude of problems regarding walking and sojourning by systems thinking and substantiating expected problems by using combined data resources. It became clear that an average citizen spends almost as much time in public space as a pedestrian than as he does in a car. Another important lesson is that injuries due to falls cause much more loss and distress than the notorious crossing accidents and that the danger of that car traffic causes probably is less important quality factor than limited walking competences and relatively low task performance by vulnerable pedestrian groups like children, the elderly and the handicapped.

Although falls constitute the most important safety problem for pedestrians, the safety of street crossing still deserves abundant attention. Crossing facilities need to be safe, comprehensible and convenient. Since crossing a road involves a complex task, it is important to reduce the cognitive load as much as possible. Measures to reduce conflicts and conflict severity are: separation of road users by infrastructure design, improve conspicuity, speed limits, speed control, vehicle design, and driver and pedestrian education.

Obviously, the actual amount of walking relates mostly to determinants of strategic walking decisions. Here again abilities and competences are a major factor. Other important determinants are the distribution of places to go and distances towards them (proximity), built environment characteristics (convenience and attractiveness), barriers in public space, availability of certain modes, availability of information systems and other essential services that are needed along the way. Furthermore security, income, education and social barriers play an important role in walking and sojourning decisions on the strategic activity level.

Public transport can be seen as the ‘natural’ extension of walking. Especially for citizens that have no private (motorised) transportation means (the majority of the population...)

availability of public transport facilities is a primary requirement. Short walking distance to the public transport stop comes second. Next walking comfort plays a role. The attractiveness can be calculated through a formula that is provided in a dedicated article in the report.

Intelligent Transport systems can simplify on-trip tasks while walking. There are a number of application areas: for getting contact or localising, for navigation, for alerting or informing of dangers, for adapting the environment to pedestrian conditions, for promoting security and for supporting pedestrians with special needs.

Route choices are affected by a number features. The most important one is distance. Other relevant quality factors are physical access: safety, accessibility, attractiveness, and comfort. Additionally there are 'soft factors': trip purpose, personal fitness and moods. There are trade-offs between distance and quality.

One of the distinguishing features of a system approach is that it entails a multitude of strategies and policies combined to improve the pedestrian's situation. It seldom relies on one single category of measures, discipline or strategy to achieve improvements. It covers a wide range of actors and a wide range of strategies to support and promote walking and sojourning in public space. It all starts with knowledge and awareness of the issue. Main categories of policies and strategies discerned are: Land use and transportation policies for setting the stage for making it more possible and attractive to walk, Safety policies and strategies, Acquiring knowledge to improve the quality and effectiveness of policy development and measures, Stimulating planning and action, Encouraging and facilitating walking (campaigns) and Lobbying and providing incentives or structures for making it happen.

The mother of action for the improvement of walking and sojourning in public space is design of public spaces. Architecture has 'always' played a leading role and this still is the most successful field in promoting walking. Public space designers produce tangible and measurable effects. The most important indicators for walking and sojourning quality are the amount of space devoted to pedestrian mobility, the density of the pedestrian network, the amount of streets with traffic calming, the amount of parking areas and accessibility of public transport. Important measures concern: providing for pedestrian activities, at least based on minimal requirements for the amount of space needed; traffic calming with 'chokers' and pedestrian refuges; speed control at street crossings; street closures for sojourning activities; shielding against extreme environmental conditions (heat, wind, humidity, noise etc.); provision of seating and other useful street furniture; application of comfortable, attractive, safe and durable materials.

Introduction to the Functional Needs section.

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Introduction

This section of the PQN Final Report covers the output of the PQN Working Group 1 Functional Needs. The stage for the research and reporting is set by the main aim of the COST 358 Pedestrians' Quality Needs (PQN) project: to demonstrate the added value of a systems approach to supporting walking and sojourning in public space. Such a systems approach is build on three principles:

1. Start with the pedestrian
2. Analyse of the system comprehensively
3. Apply the Cascade principle for policy development and implementation[1].

Policy development using a systems approach will result in a multi-level, comprehensive and integral improvement programme proposal. To be successful, the proposal should not only take into account interests of pedestrians, but also those of other stakeholders, particularly the ones that might suffer consequences. In general it will be a big plus if the program connects effectively to other, accepted policy plans for economic development, urban planning, transport and mobility planning, planning for the environmental, safety and health.

With regard to the analysis of the issue it was agreed[2] that comprehensive coverage of the issue means that the Action looks at the issue from three perspectives, the functional perspective, the perception perspective and the durability and future prospects perspective:

1. *Functional perspective*:
   Functionality or usage value, relates to what is being offered and to intrinsic quality supply. It concerns looking at the system from the 'head' and searching for 'facts', thus covering first order[3] needs and wants. This perspective particularly covers the experts' perspective and focuses on the supply side of facilitating pedestrian activity.

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[1] The Cascade principle implies that the first step in policy making is to take care that preconditions (knowledge, political will, competences and necessary means) for realisation of targets are in place. If this condition is fulfilled to a reasonable degree, then there is a good base to start to work on providing for desirable strategic walking and sojourning choices. Following that, tactical walking and sojourning decisions (i.e. routing, network, orientation) need attention. Finally, when these conditions are met as much as possible, attention should be paid to the details: concrete measures to support the actual walking and sojourning behaviour (see PQN Final Report Part A: Introduction and Conceptual Framework).

[2] see COST 358 Memorandum of Understanding (COST, 2006) and PQN Final Report Part A: Introduction and Conceptual Framework.

[3] according to Rumar (1999) there are three kinds of problems that need to be dealt with: first order problems, that can be identified from available data, second order problems, that come forward through dedicated studies and third order problems that are almost totally hidden.

2. *Perception perspective*:
   The perception perspective relates to what is being requested and to subjective quality needs. It concerns looking at the system from the 'heart', including attitudes towards and of pedestrians, thus searching for 'opinions' and covering second order needs and wants. On the one hand this perspective covers the pedestrians' perspective and focuses on the demand side of facilitating pedestrian activity and on the other hand on public and political opinions that influence policy making and implementation on the issue.
3. *Durability and Future Prospects*:
   Whilst the functional perspective and the perception perspective are mainly static[4] quality descriptions, the durability and future prospects perspective refers to a dynamic perspective and so called third order needs and wants. Durability[5] is, like user value and perception value, a relative value and depends on current qualities, future social values and future use of the physical environment and transport system. Historical developments can be described in 'objective' terms, but assessment of future prospects and durability are, because of the uncertainties involved, by nature at best expert opinions. Because interventions can have substantial impact on future developments, this kind of assessment is needed for balanced decisions that take into account, as well as we can, the interests of pedestrians in the future. It goes without saying that this perspective particularly covers the experts' perspective.

In order to get a complete and balanced picture, the three perspectives need to be collated into a fourth perspective: the integrative perspective, that seeks to find ways to balance out the different realities of the 3 'longitudinal' perspectives into coherent policy and research recommendations from the perspective of a generalised pedestrian. Therefore, in the PQN project there are four working groups, each taking up one of the four perspectives.

This section of the report deals with the results of work done by Working Group 1 Functional Needs, including also some other 'general' project activities results like the Country Reports that each of the participating countries produced as well as a paper on pedestrian safety data that is gratefully taken up from the sister project on the pedestrian issue by the OECD / International Transport Forum called 'Pedestrian Safety, Urban Space and Health'.

1. Working Group 1 aims

The most basic order of needs covers the 'rational' perspective of the current situation. Working Group 1 focussed on the physical and observable ('objective') needs of pedestrians, visible and objective behaviour and the 'technical' ergonomics with regard to the physical and social environment and the transport modalities.

Research explored the presence and behaviour of pedestrians in public space, and the relationship and influence of mobility, safety, physical health and exclusion.

Insight in needs and the degree to which they are satisfied was gathered by the following approaches:

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[4] indication of the situation at a given moment

[5] Durability and robustness are strongly related concepts. In statistics robustness is defined as insensitivity against small deviations in the assumptions. Aspects are system performance and loss of function, collapse of powers with overall consequences that are scenario dependent, robustness and vulnerability, from component design to systems design (MoU of COST TUO601, 2006).

- find out what pedestrian activities, risks and ergonomic misfits are observed and reported
- find out what recorded norms, policy objectives and solutions there are with regard to facilitating and supporting pedestrian activities
- analyse inter-relations between offered facilities and observed pedestrian activities and risks.

2. Methodology, process and coverage.

The first step in the analysis process was to identify a number of key questions to be researched. The research questions are derived from the Conceptual Framework and were to cover the issue comprehensively. In fact the questions concern all elements in the system (pedestrian, other humans in the environment, the physical environment, the social environment and transportation) as well as the pedestrian’s activity levels (Lifestyle & strategic decision, tactical decisions and operational behaviour). The questions that were identified are:

A. What is known about presence, mobility and safety characteristics of pedestrians in public space?
B. To what extent do initial choices regarding residence, work place, recreation and social relations influence walking options?
C. What ‘objective’ factors and mechanisms determine the pedestrians’ travel and/or sojourn motives?
D. Which physical and safety needs do they relate to?
E. What ‘objective’ factors and mechanisms determine the pedestrians’ routing and sojourn decisions and safety precautions taken?
F. What tasks are pedestrians to perform?
G. To which extent are individuals able to perform these tasks and what groups can be distinguished?
H. Which facilities and provisions are (implicitly) required for performing the tasks adequately?
I. What are the risks?
J. What are the (basic) risk factors and what are favourable factors?
K. What factors determine pedestrian quality from a functionality perspective?
L. What measures, interventions, policies ands strategies can improve the pedestrians' situation?
M. What integral policy programs need to be recommended in relation to their context?

Because of the limited number of participants in the PQN project Working Group 1 and the focus of their interest, not all key research questions could be uniquely allocated. Some chose to cover a question in total, others chose to only deal with a sub-question from their expertise. In total all elements of the system and all activity levels were at least to some extent dealt with. In the project’s context it was not an option to enforce equal and consistent coverage (if at all possible). The PQN project group was aware that at the end of the project there would be gaps in coverage, to be dealt with in future projects.

The study work concentrated on reviewing literature, gathering available statistics and re-interpretation of available research data and internal working group discussions (8 meetings across the four yours lifetime of the project). Apart from the Country Report questionnaire, no original surveys were undertaken. Whenever possible the work resulted in recommendations regarding standards for land use, public spaces, information, legislation and transport modes, allowing for substantially different situations in the participating countries and sub-regions.

For quality control all papers were reviewed internally by other partners in the working group and most of the papers were externally reviewed. The reviews did not target at achieving the extreme high scientific standards used for scientific journals like Accident Analysis and Prevention and the Transportation Journal. The aim of the reviews was to safeguard usefulness for practitioners and to provide inspiration for further research.

3. Structure of the WG1 report

Like all sections in the PQN Final Report Part B - Documentation, the section of the report starts with a summary and an introduction to the section papers. The following papers concern the content results of the working group's doings:

Papers on data availability and conclusions from statistical sources:

- B.1.3. Assessing the pedestrians' environment (based on international databases and the Country Reports)
- B.1.4. Data on pedestrian mobility and safety (concerns the availability of statistics)
- B.1.5. Pedestrian risk and risk factors (concerns data on safety and how they should be interpreted)
- B.1.6. Pedestrian safety data (provides an overview of data on prevalence and causes of pedestrian accidents) – courtesy of OECD/ITF

Papers on pedestrian needs, abilities and opportunities on the Lifestyle and Strategic activity levels:

- B.1.7. Tasks of pedestrians and principles for simplification of pedestrian tasks
- B.1.8. Determinants for strategic decisions concerning walking
- B.1.9 ITS and on-trip tasks while walking

Paper on the pedestrians' tactical activity level decision making

- B.1.10. Parameters route choices in walkable networks

Papers on the pedestrian's needs, abilities and opportunities on the operational activity level:

- B.1.11. Functional abilities and the identification of functional groups
- B.1.12. The safety of pedestrian crossing
- B.1.13. Walking accessibility of public transport modes

Papers on interventions that can improve walking and sojourning conditions

- B.1.14. Interventions, strategies and policies that can improve the pedestrian's situation
- B.1.15. The design of the walking environment
- B.1.16. Summary of the Country Reports

A paper on conclusions drawn from the Working Group 1 results:

- B.1.17. Conclusions

A qualitative approach to assessing the pedestrian environment

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Summary

European cities have always been attentive to the needs of pedestrians, and walking has traditionally been the prevailing means of transport. However, during the last century, car driving has been granted increasing priority in investment programs, and the rising urban car dependency has negatively affected pedestrians quality needs (PQN). Because of these problems, European cities will have to differently approach car-oriented policies, aiming at a more sustainable design and transport planning, as well as an effective mobility management. Generally, countries appear to be on the right path, and there are several examples of pedestrian-friendly cities. However, more needs to be done and in the European context there are too many disparities between countries performing at different levels.

This article presents the PQN matrix, a qualitative approach to assessing pedestrian environment, which translated pedestrians' quality needs into five basic requirements: connectivity, conspicuity[2], comfort, convenience and conviviality. This framework only takes into account the connection between pedestrians' needs and the environment, whilst neglecting the other three components of the system, i.e. person, vehicle and organisation. A practical application is also provided, through the analysis of twenty pedestrian-friendly cities in the countries taking part in COST Action 358. This analysis aims at developing a comprehensive comparison among these cities, stressing their differences and similarities.

This article is based on the key findings achieved by the Short-Term Scientific Mission (STSM) that took place in February and March 2008 at AVV Transport Research Centre DVS in Rotterdam (The Netherlands)[3].

1. Introduction

Walking seems to have declined over the past decades as a means of transport, and it has turned into an increasingly difficult activity for specific categories of users, such as people with limited mobility, the elderly and children (Methorst, 2005). Recently, several efforts have been made in Europe, to prioritize walking in urban areas and to develop new mobility schemes, oriented to vulnerable road users, as an alternative to past policy measures that favoured car use. As regards safety issues, the objective of the European countries is to strongly reduce pedestrian fatalities by 2010 (European Commission, 2001).

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[1] This article is the result of research conducted within the COST Action 358 as part of a Short-Term Scientific Mission carried out in cooperation with the Politecnico of Torino, Italy, which the author was associated with at the time of the study.
[2] The quality of being *conspicuous*; obviousness (www.thefreedictionary.com/conspicuity)
[3] AVV Transport Research Centre is currently named Rijkswaterstaat Centre for Transport and Navigation and is now based in Delft.

However, pedestrian environment and the cities' *walkability*[4] cannot successfully be improved if policy makers do not include pedestrians in transport planning and urban development. Moreover, walkability has to be related to the need for **quality**, a rather neglected issue in the pedestrian system. The concept of quality and its assessment has been recently been taken into account in other sectors, e.g. public transportation (UNE-EN 13816, 2003), but up till now little has been done to produce a more comprehensive approach inclusive of pedestrian quality needs and their satisfaction as "customers of the pedestrian system".

Finally, among the issues pertaining to pedestrians, technical (engineering) interventions are not sufficient to provide adequate levels of quality: policy measures also need to consider other sectors and disciplines, such as sociology, psychology, ergonomics, technology and transportation. As a matter of fact, reference to the carrying out of a comprehensive analysis of the pedestrian system takes the name of Pizza Model (Methorst, 2003), a visual checklist that summarises the four components of the pedestrian system: *person, vehicle, organisation* and *environment* (Figure 1).

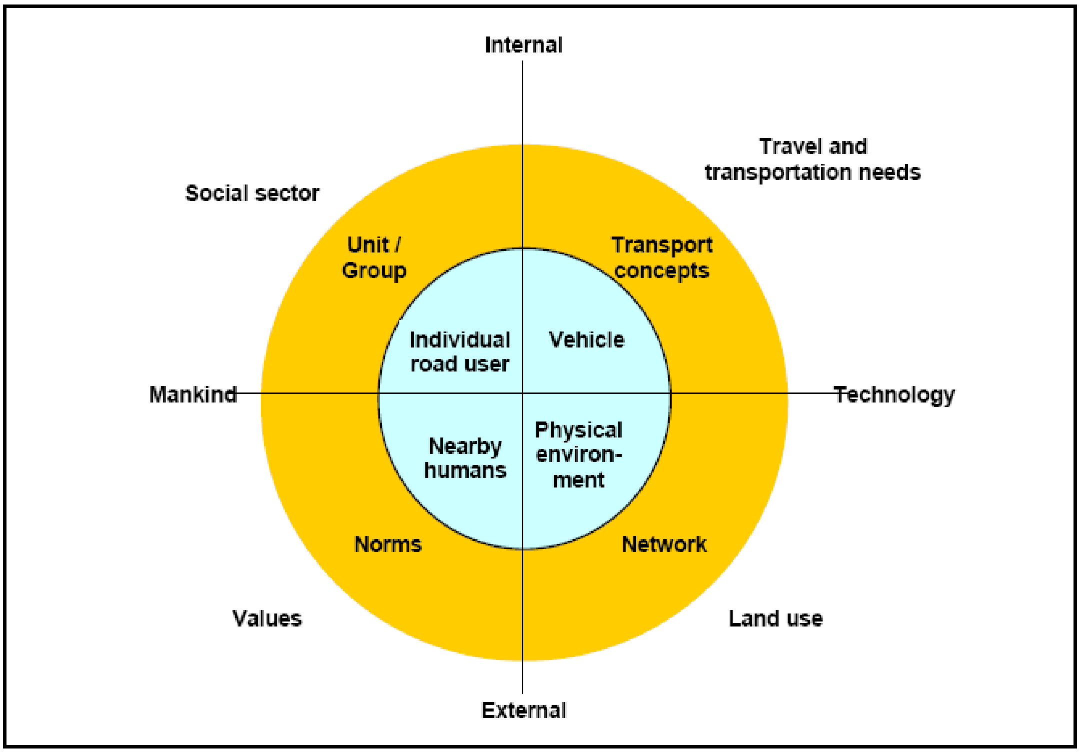

Figure 1 **Pizza Model**
Source: Methorst (2003)

The STSM was confined to one slice of the model, namely the "environment" dimension, and this article improves the knowledge on pedestrians' quality needs with regard to the spatial environment. Consequently, the assessment framework provided by the PQN matrix only focuses on one part of the pedestrian system, thus there is need for further integration and completion of the template.

[4] Walkability is the quality of walking conditions, including factors such as the existence of walking facilities and the degree of walking safety, comfort and convenience (Litman, 2003). Walkability has health, environmental, and economic benefits: it is an important concept within sustainable transport policy. However, walkability is difficult to evaluate and quantify, because of the several and subjective factors that influence it, such as the built environment, traffic and road conditions, land use patterns, human perception, and social behaviour.

2. The qualitative framework and PQN matrix

The qualitative template to assessing the pedestrian system and its level of quality is summarised in Figure 2 and is based on three aspects: context, pedestrians' quality needs and interventions. *Pedestrians' quality needs* are translated in five basic requirements that need to be satisfied in order to ensure the walkability of a specific area. The '5C layout' reflects pedestrians' desire to make their journeys in the shortest and most convenient way possible, as a safe, pleasant and comfortable journey experience. However, conditions for pedestrians vary widely from city to city and the *context* issue influences pedestrians' needs. Differences as far as climate, spatial conditions, quantity and composition of traffic are concerned set the need for different quality requirements and, consequently, for different *interventions and solutions*.

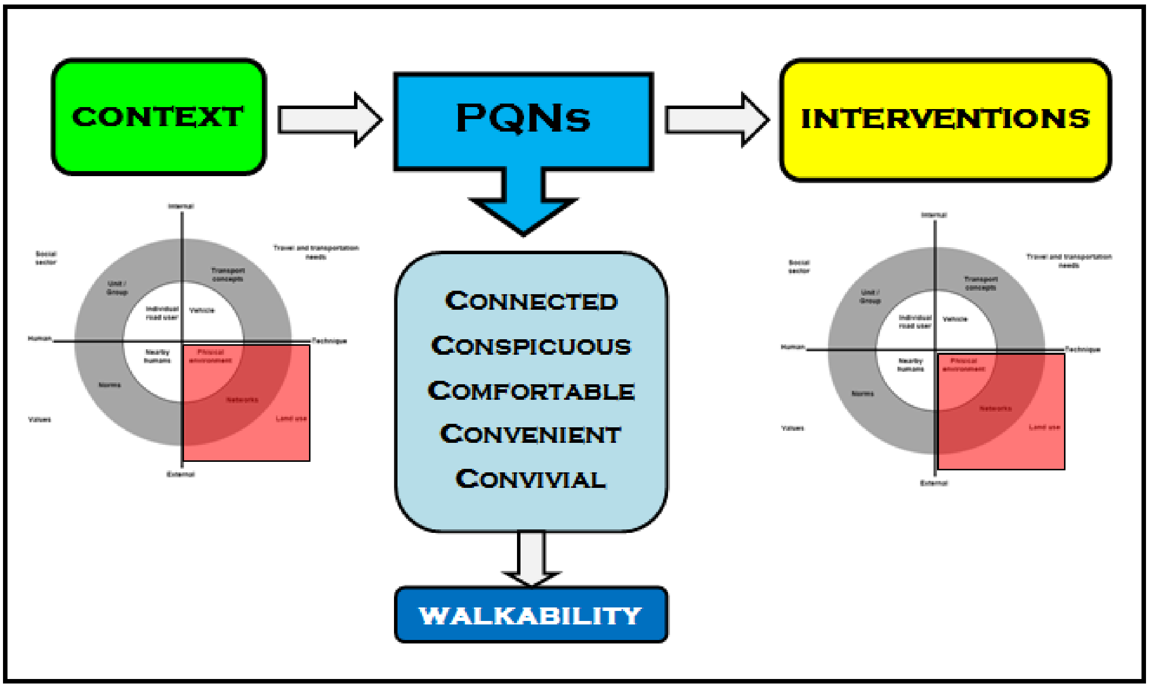

Figure 2 **Pedestrian qualitative assessment framework**
Source: own work

Therefore, in order to develop an effective qualitative framework, it is necessary to *a priori* define a series of issues of relevance to the analysis, i.e. definitions of PQNs, interventions and context items. As regards these classifications, they have been elaborated after reviewing examples mentioned in the literature, previous studies and relevant projects on the topic (ADONIS, 1998; WALCYNG, 1999; PROMPT, 2000; COST C6, 2002; Methorst, 2003).

Finally, it needs to be stressed that the work of this article develops a qualitative approach to assessing the pedestrian environment, neglecting the possibility to perform a quantitative analysis. The PQN matrix is a qualitative assessment tool and has to be considered as a template designed for data screening, pedestrian audit, walkability checklists, factorial analyses, etc.

2.1. The 5C layout

Almost the entire world population happens to be a pedestrian at some time or the other. The term 'pedestrian' encompasses a wide range of people and, consequently, the determination of quality needs is ambiguous and human perception and experience play an important role. From the literature, it appears that a large number of theories and classifications have been developed with regard to needs (such as Maslov, 1943; Alderfer, 1969; Van Hagen, 2006). This work identifies five factors, so that the analysis is founded on the *5Cs layout*, frequently used to classify and prioritise pedestrians' needs (Transport for London, 2005).

Therefore, pedestrians' needs are considered relative to the "5Cs", meaning that walking networks and facilities should be connected, convivial, conspicuous, comfortable and convenient. This layout is in accordance with the concept of walkability since, as stated by Risser (2003), *quality* for pedestrians is subjective and depends on the options for choices, the ease of the realisation process and possibly the comfort and pleasure derived from, on the one hand, the activities, and on the other, all social, economical, political and environmental factors and the perception of these conditions.

The five "Cs" are here defined in succession:

CONNECTED

The extent to which the pedestrian network links to key trip origins and destinations, as well as the extent of linkages between different routes on the network.

Features
- Undisturbed route between origin and destinations (yes/no).
- Absence of obstacles and obstructions.
- Access to public transport nodes (bus stops, railway stations).

CONVIVIAL

The extent to which walking is a pleasant activity, in terms of interaction with people, the built and natural environment, and other road users.

Features
- Absence of conflicts with other means of transportations (car, bicycle, moped, segway) and absence of threats and assaults.
- Absence of rubbish, potholes, roots, damaged surfaces.
- Adequate street furniture, benches, "places to stop".

CONSPICUOUS

The extent to which walking routes and public spaces feel safe and inviting for pedestrians, in terms of clear and legible signing and information.

Features
- Lighting and visibility.
- Delineation and legibility.
- Traffic signs: information and orientation.

COMFORTABLE

The extent to which walking is accommodated to competences and abilities of all types of pedestrians.

Features
- Well maintained footpaths of adequate widths, smooth surface and with few obstacles (steps, mud, etc).

- Attractive landscape design and architecture, and provision of rest places opportunities.
- Absence of noise and fumes from motor traffic.

CONVENIENT

The extent to which walking is possible and able to compete with other modes of transport in terms of efficiency (time, money and space).

Features

- Road crossing opportunities: location, type, waiting time.
- Walkable distances between key destination and directness.
- Absence of barriers, changing level (steps and slopes) and discomfort.

2.2. The physical context

Pedestrians have to face with a physical environment that is strongly affected by the nature and geography of the territory - that is, internal properties -, but also by the built environment and the urban and transport planning - external characteristics.

After a literature review regarding context features related to pedestrians (Lynch, 1960; Buchanan, 1963; Cervero & Kockelman, 1997; USEPA, 2001; Ewing et al, 2006), the following items have been identified, since they recall the 3-layers approach of the Pizza Model:

Item 1 : <u>Site</u>

⇨ Buildings

How hight are they?
Are blocks compact?
How are they oriented and aligned with respect to the footpath?

⇨ Road intersections

How many intersections are there?
What type of intersections are there?
What is the density?

⇨ Architectonical and historical buildings

Are there historical buildings?
Are there architectonical buildings?
Are there heritage sites?

Item 2: <u>Network</u>

⇨ Road network characteristics

How wide are the roads?
What is the speed limit?
Do the roads have a clear function?

⇨ Topography

Is the terrain flat?
What is the altimetric profile?
Are there substantial height differences in height?

⇨ Presence of barriers, e.g., streams / rivers / etc

Are there rivers or streams?
Are there channels?
Are there lakes?

Item 3: Space

⇨ Climate conditions

What is the average temperature in winter and summer?
What about the wind and the precipitations?
What about humidity?

⇨ Urban design

What is the city planning?
Are there special districts?
What about the old town?

⇨ Distribution of commercial activities, residential zones and essential destinations

What is the amount of the urban sprawl?
Which is the residential density?
What is the location of shops for daily necessities, health centres, schools, bank/ post offices, playgrounds and public transport stops?

2.3. Interventions and measures

Focusing on the "spatial environment" slice of the Pizza Model, interventions and measures are important for the improvement of the overall urban quality of the space in which pedestrians move, and they can be classified according to different criteria[5]. On the basis of a large review of literature projects and research (Dykstra et al, 1998; Biddulph, 2001; Olof Gunnarsson, 2001; PROMISING, 2001; COST C6, 2002; Transportation Research Board, 2003), the analysis is based on the scale classification, in order to make it compliant to the 3-layers of the Pizza Model:

Item 1 Site

⇨ *Crossings Interventions*

- Provide adequate location (not too close or too far away from the intersections)
- Provide adequate waiting time, crossing times, information technology (if signalised)
- Provide adequate capacity (waiting areas, refuges, midblock islands)
- Provide traffic calming measures (humps, roundabouts, curb extensions, raised crossings, intersection radii, rumble strips)
- Provide dropped kerbs, ramps, at-grade crossings
- Prevent car parking and obstacles
- Provide adequate legibility: marking, colour, surface, tactile information
- Provide maintenance, cleanliness (surface, litter, markings, furniture)

[5] There are different criteria to classify interventions, as below:
a) *Stage*: national, regional, provincial, municipal.
b) *Scale*: urban, street, site.
c) *Type*: technical, non technical.

⇨ *Public Transport Waiting Areas Interventions*

- Provide adequate location (not in curve)
- Provide adequate space (platform)
- Provide adequate equipment (shelters, seatings, benches)
- Provide protections from traffic
- Provide dropped kerbs, ramps
- Reduce gaps between the transport access point (i.e door) and the footway/stand.
- Provide adequate lighting
- Provide maintenance, cleanliness

Item 2 <u>Network</u>

⇨ *Links Interventions*

- Provide footpaths with proper width, gradient (steepness) and surface
- Provide adequate street furniture location
- Reduce kerb parking
- Provide dropped kerbs, signalised driveway, recognizable building entrances
- Provide an adequate buffer between walking paths and car/bicycle lane (planter strips, parking lanes)
- Provide information and orientation signage
- Provide adequate lighting
- Provide maintenance, cleanliness (surface, litter, graffiti)

⇨ *Routes Interventions*

- Prevent barriers (adequate location of fences, parking lots, street furniture)
- Provide traffic calming measures (road narrowings, chicanes, half and full street closures /cul-de-sac, lateral shifts)
- Create an attractive walking environment (planting of trees, playing equipment, public art, fountains, statues, street cafes)
- Provide adequate linking with Public Transport Waiting Areas
- Provide adequate pedestrian bridges, overpasses, underpasses
- Provide orientation signage (maps)
- Provide adequate lighting
- Provide maintenance, cleanliness (surface, litter, graffiti)

Item 3 <u>Space</u>

⇨ *Public Spaces (rest areas, meeting places, squares) Interventions*

- Prevent barriers (adequate location of large complexes of buildings, gated areas)
- Provide street furniture (benches, litterbins) and lighting
- Provide information and orientation signage (maps)
- Provide parking measures
- Provide green areas
- Reduce noise and emissions levels
- Preserve historic centres and promote tourism
- Provide maintenance, cleanliness

⇨ *Special Zones (school, residential areas,…) Interventions*

- Provide traffic calming measures in school zones
- Plan Home zones (30 km/h)
- Plan Car free zones (especially in the city centre and in residential areas)
- Adopt speed limits (especially in school and hospital zones)
- Prevent the transit of big heavy vehicles transit in central zones
- Plan a pedestrianisation of the city centre
- Establish Road/Park Pricing measures
- Provide adequate facilities in interchange zones (stations)

2.4. The PQN matrix

The PQN matrix (Figure 3) provides a qualitative assessment of the pedestrian environment, focusing only on the "spatial environment" slice of the Pizza Model.

Based on the qualitative framework presented in the previous sub-sections, the PQN matrix can be easily developed, since it is basically a picture checklist that connects quality needs (columns) and physical measures (rows).

Context items are not included in the matrix, but are important to explain these connections and point out at differences and similarities between different case studies, when a comparison analysis is carried out.

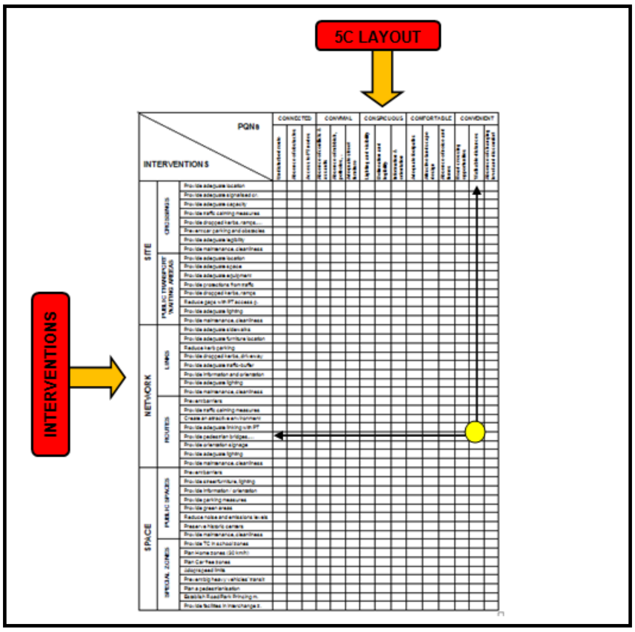

Figure 3 **PQN Matrix**
Source: own work

3. Application: 20 pedestrian-friendly cities

This section focuses on the comparison of twenty pedestrian-friendly cities, based on the qualitative framework and the PQN matrix tool presented in the previous section. Conditions for pedestrians vary widely from city to city: there are differences in the physical environment, the quality requirements and the implemented policy measures.

Although this approach is objectionable, since it is not a quantitative one, it gives an image of PQN measures in the European context of COST Action 358, providing a screening and a qualitative view of the issue, and offering useful information that can be consolidated by a further (quantitative) analysis.

3.1. The 20 cities

The analysis was extended to twenty case studies, i.e. twenty European pedestrian-friendly cities, one for each country participating in the COST Action 358. Selection of the cities was anticipated by a wide review of major European projects on pedestrian mobility and urban transport strategies (ADONIS; 1998; WALCYNG, 1999; CIVITAS, 2006). The following twenty cities were identified:

COST Action 358

COUNTRIES

Austria	Graz
Belgium	Gent
Czech Republic	Praha
Estonia	Tallinn
Finland	Helsinki
France	Strasbourg
Germany	Berlin
Greece	Athens
Hungary	Pécs
Israel	Haifa
Italy	Modena
Netherlands	Delft
Norway	Oslo
Poland	Krakow
Portugal	Lisboa
Serbia	Belgrade
Spain	Barcelona
Sweden	Lund
Switzerland	Genève
United Kingdom	Leeds

3.2. Objectives and methodology

Objectives

The general objective of the qualitative analysis follows the main objective of COST Action 358; that is, the strong will to provide a contribution to the knowledge in the frame of PQN and to assess the pedestrian environment within urban areas, stressing differences among the twenty countries involved in the Project.

The following are specific objectives of this analysis:

- to remark the importance of a qualitative approach;
- to illustrate the utility of the PQN matrix;
- to relate quality needs to structural and functional interventions in the pedestrian environment of twenty best case studies;
- to identify similarities and differences among European cities.

Methodology

The methodological aspects can be summarised in the following three steps:

1) Take stock of available data, information, research, current projects on the twenty cities.
2) Fill in the cells of the PQN accordingly to the previous step's results. The following legend is necessary to fill the matrix, since each colour represents the *number of cities that have implemented a certain measure (row) to accomplish a certain quality need (column)*.

	1 – 4 cities
	5 – 8 cities
	9 – 12 cities
	13 – 16 cities
	17 – 20 cities

3) Comment and interpret the PQN matrix, stressing similarities and differences among the cities and drawing conclusions on how they have implemented policy measures to assure a connected, convivial, comfortable, conspicuous and convenient pedestrian environment.

3.3. Main findings

This section presents the main results provided by the PQN matrix's analysis. The PQN matrix (Table 1) allows a comparison of cities (countries) drawing conclusions on how the they implemented physical measures to accomplish specific quality needs. Here, main remarks for the three layers of interventions are presented.

- Site interventions

As regards Crossings Interventions, several cities have implemented devices to improve the quality of crossings, and some of them have done remarkably well in this framework. Interventions are mainly directed at providing the crossing with adequate location, waiting and crossing time, information technology, capacity, as well as traffic calming measures (humps, roundabouts, curb extensions, raised crossings, intersection radii, rumble strips), dropped kerbs and ramps. Finally, adequate legibility and maintenance and cleanliness programmes are also necessary.

Particularly, six cities stand out for their achievements in this context: **Graz** (zebra crossings in transverse direction, rebuilt of crossings near PT waiting areas), **Praha** (special lights, coloured surfaces, new traffic lights, central islands, narrowing roads at zebra crossings, traffic-safety equipment), **Berlin** (LED traffic lights, touch sensitive buttons and audible signals, midblock refuge-islands), **Delft** (traffic lights, push buttons with audible feedback, traffic calming devices), **Lund** (islands and medians, audible information) and **Genève** (road islands, traffic light regulation, lowered kerbstones). Spain and the United Kingdom also improved pedestrians crossing sites through the installation of lowered kerbstones (**Barcelona**) and Pelican and Puffin crossings (**Leeds**). It can be noticed that traffic calming measures are strongly implemented in crossing sites, as it can be observed from the dark colour of the cells.

As regards <u>Public Transport Waiting Areas Interventions</u> (bus and tram stops, taxi ranks), they have also been implemented in the twenty case studies. Specific measures in these areas regard their location (not in curve), space (platform), equipment (shelters, seatings, benches) and the provision of ramps, dropped kerbs, lighting, etc.

Some cities that have implemented such measures are **Graz** (rebuilt of bus and tram stops, waiting shelters, curb stones), **Gent** (enlarging of platforms, new locations, equipment), **Barcelona** (platforms, dropped kerbs, cleanliness), **Praha** (platforms, ramps), **Helsinki** (platforms) and **Leeds** (bus docking, raised kerbs, high quality shelters, lighting). **Tallinn** and **Belgrade** also improved PT quality in recent times and site interventions were included in their City Planning. However, not all the cities have been improved Public Transport facilities in the last years and the (light) colour intensity of the cells reflects this observation.

- *Network interventions*

As regards <u>Links Interventions</u>, almost all cities have implemented devices to improve links' quality. Particularly, cities in Eastern European countries focused on this kind of interventions, that include (mainly) the provision of adequate footpaths (width, gradient, surface), street furniture, street lighting and information signage.
Examples can be found in **Belgrade** (footpaths width and surface, ramps, equipment, lighting), **Praha** (traffic-safety equipment), **Tallinn** (footpaths maintenance, buffer from cars and bicycles, reduction parking lots), **Athens** (footpaths width and maintenance, reduction of parking lots) and **Krakow** (re-paving of footpaths, ramps). All cities have planned and carried out the following kinds of intervention: footpaths surface and small piles (**Gent**), widening of footpaths and pavement edges lowered to road level (**Strasbourg**), concrete bollards and buffer between footpaths and roads (**Berlin**), widening of footpaths (**Barcelona**), footway maintenance and lighting (**Leeds**). The 4th row is the most intensely coloured, since the provision of dropped kerbs is one of the main objectives of almost all cities, whilst the other rows present lighter colours.

As regards <u>Routes Interventions</u>, all cities have also implemented devices to improve routes' quality. Interventions include the adequate location of fences, guardrails, parking lots, street furniture in order to prevent barriers and make pedestrians displacements more direct and convenient. Traffic calming measures (road narrowings, chicanes, half and full street closures /cul-de-sac, lateral shifts) are also included in this context, as well as the creation of an attractive walking environment (planting of trees, playing equipment, public art, fountains, statues, street cafes) and the provision of linking with PT, pedestrian bridges / overpasses / underpasses, lighting and signage.

Cities that have distinguished themselves in this context are **Graz** (strolling zones, street lighting), **Helsinki** (route and kerbs maintenance, the construction of overpasses and underpasses, Anti Graffiti Project), **Berlin** (traffic calming, speed limits, orientation maps), **Haifa** (new walkways), **Modena** (traffic calming, speed limits, pedestrian paths), **Delft** (new pedestrian paths, reduction of parking lots, traffic calming measures), **Oslo** (traffic calming, street lighting), **Lund** (reduction of parking spaces, traffic calming, lighting) and **Leeds** (speed restrictions, traffic calming). Finally, route maintenance and the creation of an attractive environment are strongly related to the renewal of the city planning and urban design and the cities that have best performed in this case are **Barcelona**, **Helsinki** and **Strasbourg**.

- *Space interventions*

As regards Public Spaces Interventions, all cities have implemented devices to improve the quality of rest areas, meeting places and squares. Measures include the adequate location of large complexes of buildings and gated areas, the provision of street furniture, lighting, green areas, parking measures. Programmes aimed at preserving historic centres and promoting tourism are also considered in this area, as well as maintenance programmes. Among the twenty study cases, both big and small cities have implemented measures directed at public spaces.

The cells with most intense colouring are those related to the provision of green areas and parking measures, and this could be explained by the urban design renewal that many cities have carried out in recent times. Particularly remarkable are the interventions carried out in the following cities: **Graz** (planting of green spaces). **Praha** (pedestrian precinct and maintenance of squares), **Tallinn** (re-surfacing squares, benches), **Helsinki** (caring for the vegetation, maintenance of fixtures, equipment and walking paths), **Strasbourg** (reorganisation of public squares, planting of trees, art works), **Berlin** (street trees, environmental zones), **Pécs** (rehabilitation of streets and squares), **Modena** (enlargement of green areas, benches, lighting, new playgrounds), **Delft** (playgrounds, planting areas, lampposts, street furniture), **Krakow** (repaving of squares), **Lisboa** (rehabilitation of squares and city gardens, street furniture), **Barcelona** (street furniture and lighting, planting trees, space for leisure) and **Genève** (new squares and playgrounds, fountains / monuments / statues, lighting).

As regards Special Zones Interventions, almost all cities have implemented devices to improve pedestrian environment in school and residential areas (mainly). Interventions include traffic calming measures in school zones, Home Zones and/or Car Free Zones planning, the implementation of speed limits, measures to prevent the transit of big heavy vehicles in central zones, parking measures and the provision of facilities in interchange zones. Pedestrianisation of the city centre has been planned in almost all twenty cases, as the intense colour of the cells suggests. Interventions in school zones are also largely implemented: **Graz** (school mobility management), **Gent** (speed limits, traffic calming, lighting), **Strasbourg** (crossings at school entrances, safety barriers), **Modena** (school mobility management, signage), **Delft** (traffic calming, walking programmes), **Genève** (mobility management, roundabouts, signage) and **Leeds** (Safe Routes to School). At the same time City Councils have focused on residential areas and the introduction of Home Zones or Zone 30 is widespread in several cities (particularly: **Graz**, **Gent**, **Delft**, **Oslo**, **Barcelona** and **Lund**). Pedestrian environment has improved through parking and heavy vehicles measures too, as it was demonstrated by the experience of different cities (look at the intense colour of the cells), such as **Graz**, **Praha**, **Helsinki**, **Athens** and **Lund**.

Table 1 PQN Matrix: application to 20 pedestrian-friendly cities

INTERVENTIONS \ PQNs			CONNECTED			CONVIVIAL			CONSPICUOUS			COMFORTABLE			CONVENIENT		
			Undisturbed route	Absence of obstacles	Access to PT nodes	Absence of conflicts & assaults	Absence of rubbish, potholes,…	Adequate street furniture	Lighting and visibility	Delineation and legibility	Information & orientation	Adequate footpaths	Attractive landscape design	Absence of noise and fumes	Road crossing opportunities	Walkable distances	Absence of changing level and discomfort
SITE	CROSSINGS	Provide adequate location															
		Provide adequate signalised cr.															
		Provide adequate capacity															
		Provide traffic calming measures															
		Provide dropped kerbs, ramps,…															
		Prevent car parking and obstacles															
		Provide adequate legibility															
		Provide maintenance, cleanliness															
	PUBLIC TRANSPORT WAITING AREEAS	Provide adequate location															
		Provide adequate space															
		Provide adequate equipment															
		Provide protections from traffic															
		Provide dropped kerbs, ramps															
		Reduce gaps with PT access p.															
		Provide adequate lighting															
		Provide maintenance, cleanliness															
NETWORK	LINKS	Provide adequate footpaths															
		Provide adequate furniture location															
		Reduce kerb parking															
		Provide dropped kerbs, driveway															
		Provide adequate traffic-buffer															
		Provide information and orientation															
		Provide adequate lighting															
		Provide maintenance, cleanliness															
	ROUTES	Prevent barriers															
		Provide traffic calming measures															
		Create an attractive environment															
		Provide adequate linking with PT															
		Provide pedestrian bridges,…															
		Provide orientation signage															
		Provide adequate lighting															
		Provide maintenance, cleanliness															
SPACE	PUBLIC SPACES	Prevent barriers															
		Provide street furniture, lighting															
		Provide information / orientation															
		Provide parking measures															
		Provide green areas															
		Reduce noise and emissions levels															
		Preserve historic centres															
		Provide maintenance, cleanliness															
	SPECIAL ZONES	Provide TC in school zones															
		Plan Home zones (30 km/h)															
		Plan Car free zones															
		Adopt speed limits															
		Prevent big heavy vehicles' transit															

		Plan a pedestrianisation															
		Establish Road/Park Princing m.															
		Provide facilities in interchange z.															

Source: own elaboration

Furthermore, the following general considerations can be pointed out:

a) Looking at the distribution of the coloured cells in the matrix, it is clear that there are areas with different concentrations and some voids (white cells) too. It can be noticed that interventions must be apt to warrant the 5Cs not one by one, but simultaneously. In practice, interventions are interrelated to the 5Cs, i.e. pedestrians' quality needs, through a non-biunivocal correspondence: some PQNs can be achieved with different interventions and interventions can bring about different PQNs. For example, *connectivity* is mainly related to the network level, while *conveniency* is not primarily affected by space interventions. *Conviviality* and *comfort* are more related to space interventions indeed, while *conspicuity* presents a quite homogeneous distribution among the three interventions layers.

b) The PQN matrix does not illustrate the role of the context issue within the analysis; nevertheless, the influence of the physical context is enormous, since it is the key to explaining the colour's intensity of the cells, that means the similarities and differences among the cities. In Table 2 five examples are presented, that provide evidence for the connection among context, quality needs and measures within the pedestrian system.

Table 2 Connection among context items, pedestrian needs and interventions

Cities	Context item	Physical measures	Example photo
Gent Tallinn Helsinki Oslo Lund	Climate conditions	Maintenance of footways is important to avoid stumbling and falling accidents in countries with a snowy and icy climate. Moreover, Public Transport equipment includes shelter and special weather protection in Nordic cities. These measures relate to the quality need of **comfort**.	 *(Helsinki – FI)*
Graz Gent Praha Strasbourg Berlin Delft Barcelona Genève Leeds	Presence of barriers	Footbridges and underpassess to avoid detours and provide direct walkways are related to the presence of rivers or channels, that are natural barriers within pedestrian spatial environment. These measures relate to the quality need of **connectivity**.	 *(Barcelona – ES)*

Praha Berlin Strasbourg Athens Barcelona	Architectonical and historical buildings	In touristic cities priority measures have been pedestrianisation of the city centre and rehabilitation of squares and green areas, as well as the provision of street furniture, to create a safe and pleasant place where to walk. These measures relate to the quality need of **conviviality**.	 *(Praha – CZ)*
Haifa Athens Lisboa	Topography	Pedestrians aim at following the shortest and most direct path to their destination. For example, pedestrian stairways can make a big difference in hilly terrain or cities with a unique topography and local altitude differences. These measures relate to the quality need of **convenience**.	 *(Haifa – IL)*
Strasbourg Berlin Barcelona Helsinki Genève	Distribution of activities	The provision of information regarding shops, schools, banks, hospitals and, above all, the financial district is necessary in medium and big-sized cities where the distribution of activities is extended and sometimes dishomogeneous. These measures relate to the quality need of **conspicuity**.	 *(Leeds – UK)*

Source: own work

c) The PQN matrix and the qualitative framework within the STSM have focused on the “spatial environment” slice of the Pizza Model, as it was emphasised throughout the article. However, (physical) interventions and measures are also related to the other three dimensions of the model and the following three examples best help to understand this observation:

- PM slice: *person* — City with high natality rate and many children (e.g.: Delft): implementation of traffic calming schemes around school zones and mobility management for home-school based trips.
- PM slice: *vehicle* — City with a car-oriented mentality and an old vehicle fleet (e.g.: Athens): implementation of pedestrianisation and parking policy to reduce car use and improve walking.
- PM slice: *organisation* — City with a weak transport policy and regulatory development (e.g.: Krakow): implementation of traffic calming measures and speed limits.

4. Conclusion

What stands out from this article is the importance of developing a framework to assess pedestrian environment, from both a qualitative and quantitative perspective. Although a qualitative analysis runs the risk of being perceived as less useful than a quantitative one, it provides relevant information if it is based on a framework developed from literature studies and experience within pedestrian issue.

Particularly, two main remarks follow from this work:

1) Three items should be considered when assessing the pedestrian environment: context, quality needs and interventions on the physical space. As regards pedestrian quality needs, they are translated in the “5C layout”: connectivity, conviviality, conspicuity, comfort and convenience.
   The PQN matrix, based on the qualitative framework, is a picture checklist that connects quality needs and physical measures, with the objective of assessing pedestrian environment.
   The qualitative approach has only considered the “spatial environment” of the Pizza Model and it would be interesting to expand the assessment framework to the other three dimension of the pedestrian system: person, vehicle and organisation.

2) The application to the twenty pedestrian-friendly cities aims at providing useful information on the current PQN measures and quality needs, evaluating the European condition from a general approach.
   From the PQN matrix analysis, it can be noticed that interventions must be apt to warrant the 5Cs not one by one, but simultaneously.
   Although context items are not included in the PQN matrix, they are the key factors in explaining similarities and differences among cities (countries). Particularly, “space interventions” are implemented in almost all cities, while more differences can be observed in the other dimensions (site and network), due to differences in the physical context of the case studies (e.g.: the presence of a river, the size of the city, the geography of the area, the climate conditions, etc).

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Data on mobility and safety

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'Six honest servants taught me all I know.
Their names are: Who, When, Why, Where, What and How'
Rudyard Kipling

Summary

The urban expansion, the motorization, the work and shopping concentration in the cities outskirts have caused a constant increase in the travelling distances. Therefore, walking is getting more and more difficult and dangerous.

On the other hand, there is a great diversity of pedestrians with different requests or needs when using the urban and non-urban space, depending on their age, their movement capacity and the kind of trips they need to make, where and how (carrying any bundle or without any weight). On the other hand, as a road users group, they all share some basic safety and mobility requirements related with the environment quality and attractiveness, accessibility, signalization, comfort and capacity, interconnectivity and ease of movements in

general. When those requirements are not fulfilled, some pedestrians´ groups are more affected than others (children, old people…).

Good information on the actual conditions of pedestrians´ mobility and safety and better information on their own perceived difficulties and wishes can help to detect what are the basic needs to be met, so the most vulnerable road users can easily choose to walk more frequently. The city and all it spaces must be accessible (accessibility norms) for all the citizens, independently of their age and different characteristics. The space they have to use when they walk out of towns also has to be easy, attractive and safe.

Until now, available knowledge of the walking conditions and the safety of those road users have been incomplete and lacking in quality. The walkability of the pedestrians´ environment could be improved if policy makers had correct and detailed information on the actual quality needs of pedestrians in general and the specific needs of different groups of these road users.

In that sense, different sources of information on pedestrians can be considered:

a) Direct measurements

These are measures which are obtained by means of direct observation and data retrieval from a certain source. Therefore, such measures are directly captured from an instrument (in the wide sense), achieving concrete values for a certain measurement variable.

In the field of Road Safety the survey is the method most widely used to know about user's personal opinions, perceptions of needs, or self-reported difficulties with regard to mobility and safety. There is a huge disparity in the kind of data, periodicity and number of subjects considered in these studies. Different levels of Public Administrations are involved and, sometimes, surveys at three different levels can be found: local, regional or national level. But normally the mobility surveys mainly address drivers, and only little information on pedestrians can be obtained, not even the information on drivers-when they move as pedestrians.

Direct information is also the automatic data obtained by cameras or other devices used to measure the mobility of pedestrians in public spaces. Video recording is commonly used when making behavioural studies in road traffic. In order to know about mobility of pedestrians in small places or to study the pedestrian behaviour in selected streets, it is important to record it in videos and analyse them to obtain, for example, crossing behaviour patterns or to analyse conflicts between pedestrians and vehicles.

There are many examples of the usefulness of these video-based approaches. For instance, the work by Richard van der Horst (Van der Horst,1990) uses an application called VIDARTS (VIDeo Analysis of Road Traffic Scenes), where he makes a direct use of time-related measurement such as TTC (Time-to-Collision) and TLC (Time-to-Line-Crossing) as a cue for decision making in longitudinal and lateral control of the vehicle. Other time-related measures, such as the TTI (Time-to-Intersection) and TTS (Time-to Stop-Line), serve as adequate measurement for modelling driver behaviour when negotiating intersections.

One example of video analysis is a system currently used in Stockholm city (Laureshyn, 2009) to detect biking in the "wrong" direction and analyse traffic conflicts between cyclists and other road users, including pedestrians. This is done by detecting simultaneous presence of various road users in a certain area, extracting their position and speed, since video analysis provides a continuous description of road user's trajectories and speed profiles, which are important parameters to calculate safety-related indicators.

Yet, another example of a sequential analysis of the evolution of pedestrian trajectories on the crossings is the one which was computed for the detection of pedestrian-vehicles conflicts, in the work by Enrique Cabello (Cabello, 2006).

b) Indirect measurements

We consider as indirect measurements those obtained by analyzing the information provided by other means. The indirect measures showed are mainly related to pedestrian accident analysis and the information on the use of public transport.

The social impact of pedestrian accidents raises the need of knowing what happens and how. These data reflect the options they take related with time and space (days in the week, hours in the day and also some streets preferred to others), as well as the mode of public transport chosen (underground, bus, tram) associated to walking also indirectly may indicate the way they find the solution to some needs.

Usually the degree of safety is measured by the number of accidents or victims. In this sense, differences between countries reflect economic, social, infrastructural, topographical and climate conditions and, maybe, differences in policies. But there are some problems with sources of pedestrian accidents data: The most important information source for quantitative statistical crash analyses are data collected by the police or similar agencies at the national level. This is the kind of information more at hand or available. However, the weaknesses of this source of information for pedestrians´ casualties are well established almost literally quoting (ETSC report, "…." 2005a). Definition of pedestrian accident is somehow discriminative and not very good. There are problems in terms of:

- *Comprehensiveness and quality:* The data are most often based on a limited number of variables describing crash characteristics and they provide very little information about the conditions of the affected road users, not about the consequences of crashes and resulting disabilities. The completeness and accuracy of these data is not always satisfactory.
- *Underreporting:* Pedestrians (like cyclists) are heavily and disproportionately underrepresented in the police crash statistics, compared to what hospital records and other studies show (OECD, 1998). Normally the "pedestrian solo" accidents are not included. Pedestrian accidents of this kind, that do not involve any vehicle, are connected with the road footway maintenance, and their monitoring should be represented as an integral element of any sustainable transport, mobility and accessibility policy.

1. Pedestrians´ mobility, safety and reported needs.

1.1. Surveys and other data comparison by country: What we know.

Most pedestrians' safety problems are common to all European countries: Their mobility conditions have been negatively affected by the car use and the priority given to the car driving. Walking has declined over the last few decades, mainly because of the lack of accessibility, the lack of comfort, the environmental pollution and the cities unsuitable design. European countries have made several efforts in order to give priority to walking in urban areas and the target is to strongly reduce pedestrian fatalities.

Requirements to satisfy pedestrians´ quality needs, in the pedestrian-driver-vehicle-environment system, are determined by:

a) equipment
b) social environment
c) Transport system
d) Pedestrians´ abilities to manage themselves independently
e) Social values

Therefore, broader understanding of the decisions taken by the pedestrians has to include information on aspects such as the effect of ageing on their walking decisions, their concerns about security or the impact of economic and weather conditions. The social values will also influence the choices people make in relation to the transport they use to go to work, to school, to get to their leisure and sport activities.

Besides that the mobility studies mostly refer to drivers, one of the main drawbacks of the available data about mobility in Europe is the lack of a unified survey system. Almost all countries have their own survey, mainly designed to fulfil its own needs, but without a standardized procedure and quality.

The lack of a unified European survey has several main effects. Following are the most important:

- Sets of data are roughly comparable. Definition of words (trip, journey, period of time considered) can change between countries. The way which the survey is gathered can also change: by phone, by mail...
- Information is sparse on several countries web pages, some of them written in the national language. Most of these national level mobility surveys have English translation, but some of them translate only the main figures. So, even when the information is available, it is hard to find it in short time or just by clicking on few web pages.
- In addition to this national level, there are a huge number of local or regional web pages with mobility data. Web pages containing surveys with non-standard data provided by European funded research projects are placed everywhere. These kinds of data are usually tailored to the project or to the local problem, and therefore hard to compare with others.
- Surveys about mobility over short distances are mainly focused on cars or public transport. Maybe the underlying interest is the usability of these figures by local governments to collect information about its own networks of public transport. For long distances it is almost always assumed that cars or public transport are the only alternatives.

Over the next few pages, main information about mobility and safety in Europe are presented. Table I is a summary of national surveys. Following these, some figures and data about several aspects of mobility are considered. Other tables show pedestrians killed and injured in Europe.

For the collection of empirical data the STSM report, the ERSO website, ETSC Fact Sheets and national statistic, ARE(2000), Deutsche Institut für Wirtschaftsforschung (DE, 2003), Department of Transportation (UK, 2004), Bureau of Transportation Statistics (CH, 1995) and, internet sites has been used. In order to adequately update the figures in Table I, we have used the information in the last available reports from individual national Surveys, in each of the involved countries.

Information on MOBILITY:

Table I Summary of National Surveys

Country	Responsible (survey)	Survey	Fieldwork period	Age	Sample size	Information collected
BE	Federal Services of the Scientific, Technical and Cultural Affairs	Belgian national mobility survey LIMOBEL	December 1998 – November 1999	> = 6	9.459 households	Trips during a pre-selected day
DK (excl. Greenland,Faroe Islands)	Synovate and Danish transport Research Institute	Survey of Transport Behaviour (TU).	2006, 2007, 2008	10 – 84	Approx. 2.400 people per month	Traffic behaviour during the 24 hours prior to the interview
DE	German Federal Ministry of Transport, Building and Housing	German mobility panel	Autumn 2007, during one week	> = 10	904 households 1.567 people	Mobility behaviour of complete households during one complete week
ES	Ministry of Fomento (Transport)	1st part of the Mobility survey of the resident people in Spain: "MOVILIA 2006/2007", survey on short distance mobility	4th quarter 2006 (October-December) and January 2007	All	49.027 people residing in Spain	Mobility in a working day Mobility in a weekend day (Saturday or Sunday) Interview of a maximum of 4 members of each household
FR	INSEE	Survey of transport and communication	May 2007 – April 2008	> = 6	20.220 households	Daily trips during the day before and last weekend Long distance trips during the previous three months
LV	Central Statistical Bureau of Latvia	Short Distance Mobility Survey	19 May 2003 – 5 June 2003	> = 6	2476 households 6208 people	Mobility on the day prior to the interview Short distance (up to 100km according to the EU standards)
NL	Statistics Netherlands	Mobility Research Netherlands (MON)	2008	All	21.960 households 7.233 people	Journeys during one day
AT	Austrian Ministry of Transport	Austrian mobility survey	September 1995 – December 1995	> = 6	12.400 households	Daily trips during one day Trips longer than 50 km during one 14 day period
PT	National Statistical Institute	Portuguese medium and long distance mobility survey	May 1998 – June 1998	> = 15	41.845 households	Medium and long distance trips longer than 50 km
FI (excl. Åland islands)	Finnish National Road Administration, Traffic and Road Research	Finnish national travel survey	June 2004– May 2005	> = 6	20.075 people	All trips made during the survey day Over 100 km trips made during 28 days before the survey day
SE	Swedish institute for transport and communications analysis	Swedish national travel survey	October 2005 – 30 September 2006.	6 – 84	27.000 households 41.000 people	Daily mobility during one day Long-distance journeys exceeding 100 km one-way made during previous 30 days. Long-distance journeys exceeding 300 km one-way made during previous 60 days
UK (excl. Northern Ireland)	Office for National Statistics	National travel survey	January 2007 – December 2008	All	8.100 households	All personal travel within Great Britain reported in a seven-day diary for every household member. Short walks of less than a mile recorded only on the last day of the diary
NO	Institute of Transport Economics	Norwegian travel survey	2 January 2005 – 15 January 2006 A new survey will be carried out in 2009/2010	> = 13	17.500 people	Mobility during one day Any long distance trip (exceeding 100km) undertaken during the last month before the interview
CH	Swiss Federal Office for Spatial Development – Swiss Federal Statistical Office	Microcensus on travel behaviour	January 2005 – December 2005	> = 6	31.950 households 33.390 people	Concrete travel behaviour during the reference day Interview of one or two members of each household

In Table I remarkable differences can be appreciated in studied variables like the age of the population considered, the sample size or the information collected, which makes comparisons very difficult.

Table II Passenger mobility in Europe

Country	Year	Population covered – age	Average number of trips / person / day	Average travel distance (km) / person / day	Average total travel (min) / person /day
BE	1999	> = 6	3.0	:	:
DK	2001	10 – 84	2.3	30.1	40.7
DE	2002	> = 10	3.5	38.5	79.2
ES	2000	All	1.9	:	46.0
FR	1993-1994	> = 6	2.9	35.3	58.2
LV	2003	> = 6	1.9	8.7	13.0
NL	1998	All	3.4	33.6	66.1
AT	1995	> = 6	3.0	28.1	68.8
FI	1998-1999	> = 6	2.9	45.8	84.3
SE	2001	6 – 84	2.8	44.2	:
UK	1999-2001	All	2.8	29.9	59.2
NO	2001	> = 13	3.1	37.0	62.0
CH	2000	> = 6	3.6	47.6	88.8

Table II shows that in the European countries people make on average 3 trips per day and travel between 30 and 40 kilometres per day. But we do not know the number of trips made only by foot, or walking between other modalities.

Table III Average travel time/person/day (in minutes)

Country	Passenger car	Total
NO	38,9	68,2
CH	35,3	84,5
DE	43	80
ES	18,9	44,4
FR	39,0	58,2
UK	36,5	59,7
NL	32,4	59,9
AT	33,0	68,8
FI	37,7	70,7
SE	35,0	62,6

In Table III it can be seen that in the European countries with available data people spend on average an hour per day travelling. More than half of this time is spent on travel by car.

The purpose of travelling is described in Table IV. Leisure activity is the main reason, accounting for more than 40% of the time spent on travel in most of the countries with available information. Work is the second most important reason for travel.

Table IV Distribution of trips by main purpose

In percent	BE	DK	DE	ES*	FR	LV	NL	AT	PT	FI	SE	UK	NO	CH
Escort	13.9	-	-	8.3	-	3.6	-	-	-	-	-	12.6	13.0	4.8
Work/school	27.2	29.2	26.0	53.1	33.9	49.9	26.3	47.3	44.2	29.6	31.9	25.3	22.0	35.5
Shopping/personal business	28.0	29.2	40.6	8.2	32.7	22.8	23.3	21.3	7.2	21.3	21.2	31.3	25.0	19.1
Leisure	30.3	29.2	33.3	18.6	33.3	15.2	32.7	29.0	44.6	49.1	34.0	26.5	30.0	39.5
Other	0.5	12.5	-	11.8	-	8.5	17.7	2.4	4.0	-	12.9	4.3	10.0	1.0
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table V Share of kilometres travelled

Share of kilometres travelled (percentage)	Leisure	Work/School	Shopping/private business	Escort	Others	Total
Switzerland	44,8	35,0	11,2	4,9	4,8	100
Germany	38,3	29,7	21,7	4,5	4,8	100
UK	33,7	32,0	19,7	7,6	7,1	100

Table V indicates that people travel longer distances for leisure and work/school purposes, while shorter trips are made for the other kinds of reasons. Sources: Deutsche Institut für Witschaftsforschung (DE, 2003), Department of Transportation (UK, 2004), Bureau of Transportation Statistics (CH, 1995).

Table VI Personal Travel Mode Split of Various Countries.

Country	Year	Public Transport	Bike	Walk
Latvia	2003	32%	5%	30%
Switzerland	2005	12%	5%	45%
Netherlands	2006	5%	25%	22%
Spain	2000	12%		35%
Sweden	2006	11%	9%	23%
Austria	2005	17%	4%	21%
Germany	2002	8%	9%	23%
Finland	2005	8%	9%	22%
Denmark	2003	8%	15%	16%
Norway	2001	10%	4%	22%
UK	2006	9%	2%	24%
France	1994	8%	3%	19%
Belgium	1999	6%	8%	16%
Ireland	2006	11%	2%	13%
Canada	2001	11%	1%	7%
Australia	2006	8%	1%	5%
USA	2001	2%	1%	9%

Table VI points out some results of a study by (Bassett, et al., 2008) that uses various data sources to calculate overall travel (mileage) and mode split (percentage of trips) by walking, cycling and public transport for various countries. Again, it is important to note that an exhaustive comparison between them is difficult, as every country measures a different set of features.

Table VII Mode Split In Selected European Cities

City	Foot and Cycle	Public Transport	Car	Inhabitants
Amsterdam (NL)	47 %	16 %	34 %	718,000
Groningen (NL)	58 %	6 %	36 %	170,000
Delf (NL)	49 %	7 %	40 %	93,000
Copenhague (DK)	47 %	20 %	33 %	562,000
Arhus (DK)	32 %	15 %	51 %	280,000
Odense (DK)	34 %	8 %	57 %	1,983,000
Barcelona (Spain)	32 %	39 %	29 %	1,643,000
L'Hospitalet (Spain)	35 %	36 %	28 %	273,000
Mataro (Spain)	48 %	8 %	43 %	102,000
Vitoria (Spain)	66 %	16 %	17 %	215,000
Brussels (BE)	10 %	26 %	54 %	952,000
Gent (BE)	17 %	17 %	56 %	226,000
Brujas (BE)	27 %	11 %	53 %	116,000

Table VII shows the mode split mobility in various European cities (from ADONIS, 1998). The number of inhabitants does not make a clear difference. Probably, it is more a matter of suitable conditions than a question of the size of the city.

1.2. Specific information on pedestrians' mobility

Better information on the conditions in which pedestrians move gives the possibility of the evaluation of needs to be covered in order to reach higher levels of Road Safety and pedestrian satisfaction. The reasons of or motives for choosing (or not) to travel by foot is very important information that is normally overlooked. Health, economy, accessibility, comfort, interconnectivity, security, ease of movements and also the individual conditions are characteristics that may influence the decision of walking.

Specific surveys on pedestrian opinions and experiences are very infrequent. Information usually focuses on norms to cross the roads**.** Normally, only the opinions of experts have been used to consider and evaluate the situation on different countries and the way to promote walking.

One specific example of that kind of surveys, is the "Pedestrians Attitudes and Behavior" carried out in the summer of 2002 by the National Highway Traffic Safety Administration of the United States Department of Transportation, Washington, DC. The sample included 9.616 people, from 16 years old onwards.

About 86 % of people aged 16 or older walked, jogged or ran outdoors for 5 minutes or more during the summer months, with 78 % doing so within the 30 days prior to the survey. For the group over 64 years old, walking during those 30 days decreased to just 66 %. An estimated 13.33 billion walking trips were made in the summer months of 2002, with 74 % of all trips being made by frequent walkers. Personal errands (38%), exercise (28%) and recreation (21%) are the most common reasons for trips. Nearly half (45%) of the trips were made on sidewalks, and 25 % were mostly on paved roads. Just 6 % were made either on bike, walk paths, or trails. About 6 % of pedestrians felt their personal safety threatened on their most recent trip, with 62 % saying they felt threatened by motorists. Almost three-quarters of people 16 and older (73%) are satisfied with how their local community is designed for walking; though one-third would like to see changes including more sidewalks (42%) and more lights (17%).

In the Netherlands there is another, more comprehensive, pedestrian survey (Mobility 2008) that includes distance covered by foot, number of trips as a pedestrian (both as door-to-door and as multi-modal trips), specific groups and situations.

In Spain (Movilia, 2007) the collection of data during the first stage of the survey, was carried out by directly visiting people at their homes, during the last quarter of 2006.

On weekends, different modes of movement include 47% on foot (for more than 5 minutes), compared to 46% by car or motorbike, and 4% by urban bus or underground; the remainder is distributed between trips by intercity bus, train and others. Also on weekends, the time consumed by movement is larger due to walking trips, which consume approximately 45 minutes. This is longer than the average time dedicated to work, study, shopping, escorting, leisure, visiting and others.

During work days, modes of movement include 46% on foot (for just 5 minutes), against 42% by car or motorbike, and 7% by urban bus and underground; again, the remainder is distributed between intercity bus, train, and some others. As in the previous section, the largest figure is the time devoted to walking trips, which compose a total expense of around 45 minutes.

A more detailed comparison of these issues, with concrete figure, is provided in Table VIII.

Table VIII Walking trips duration and purpose

Walking time /day U.S. (Survey 2008)	86% of the sample walked 5 minutes/day or more during the summer. 78% had walked during the previous 30 days. 65% of the group ≥ 65 years old had walked the previous 30 days
Walking time /day Spain (Movilia 2007)	47% on foot (for more than 5 minutes), 46% by car or motorbike, and a 4% by urban bus or underground during weekends
Walking time /day Netherlands (Mobility 2008)	22% on foot , 20% bicycle, 53% by car + others 5%

Walking trips purpose	**Private business**	**Leisure**	**Exercise/health**	**Travelling to Work/School**
U.S. (Survey 2008)	38%	21%	28%	5%
During weekends Spain (Movilia 2007)	**Visit 19% Escorting 4% Shopping 14%**	**Leisure**	**Walking on foot 20% Others10%**	**Travelling to Work School**
Spain	37%	25%	30%	8%
During weekends Netherlands (Mobility 2008)	**Business Visit 0,5 % Visit 25 % Shopping 24 %**	**Leisure**	**Walking on foot 18% Exercise 2% Others 4%**	**Travelling to Work 6% School 0,5%**
Netherlands	49,5%	20%	24%	6,5%

SAFETY Figures:

Table IIX Fatalities and injured pedestrians

2006	Pedestrian Fatalities	Pedestrian Fatalities per million inhabitant	Injured Pedestrian	Injured pedestrian per million inhabitant
AT	110	13	4033	488
BE	122	12	4611	439
CZ	202	20	3725	363
EE	61	45	616	458
FI	49	9	601	114
FR	535	9	13609	216
DE	711	9	33226	403
HE	267	24	2756	248
HU	296	29	3640*	361
IL	139	20	3090	434
IT	758	13	21062	359
NL	66	4	1692	104
NO	35	8	867	187
PL	1756*	46*	6363	167
PT	156	15	6229	589
ES	613	14	11153	255
SE	55	6	1631	180
CH	76	10	2454	329
UK	675	11	30307	502

Though we do not know very accurately the figures of pedestrian mobility, as it is noticeable in the former paragraph, it is certain that their safety is a big worry, mostly in towns, but also in their movements out of the urban environment. The number of fatalities and injuries caused to pedestrians is extremely important. Table IIX shows that information.

The set of factors considered as the main causes of accidents involving pedestrians are the speed of motorised vehicles, the weight and design of motor vehicles, the lack of protection for pedestrians, their visibility and vehicle control and the alcohol/other drugs consumption[1]. Pedestrians, however, also have an important role to play in their own safety. Not making proper use of pedestrian crossings, crossing the road at a red light or being absentminded while using their mobile-phone or other technological devices, are common causes of accidents.

1.3. Crossing Roads Safety Norms

The contents of this section are taken from the 2008 edition of the *Pedestrian Crossings Survey* by *EuroTest*.

All countries have standards related to the planning and design of pedestrian crossings. In some countries, these national standards may be supplemented by regional standards. There is diversity in laws and guiding principles. However, one principle remains and is clearly specified in all countries: the driver is asked to pay special attention when approaching a pedestrian crossing and he has to give right of way to pedestrians. It's not only the action of using a pedestrian crossing which gives right of way, but also the evident intention from the pedestrian to cross the road. However, this last point is not clearly mentioned in the Italian legislation, for example. Furthermore, in Belgium, we can underline that the way of using pedestrian crossing is not specifically mentioned to the pedestrian. In the Netherlands, for instance, the pedestrian is not specifically asked to pay attention before using a pedestrian crossing. In Finland, the right of way of pedestrians is not mentioned in the regulation for pedestrians but only in the regulation for drivers. In Spain, the traffic law indicates pedestrians how to proceed when using the pedestrian crossing or how and where to cross when there is not a pedestrian crossing, as well as how to walk along the roads out of towns.

Regarding the material that can be used on pedestrian crossings, the use of light reflective material for stripes is mandatory in Austria, Germany, Norway and Switzerland, recommended in Finland, Great Britain, Italy, Belgium and the Netherlands and only partly specified in Spain. The use of highly skid resistant material is mandatory in Germany and Norway, recommended in Belgium, Great Britain, Switzerland, and the Netherlands and not clearly specified in Austria, Spain, Finland and Italy.

Pedestrian crossings must be safe places for pedestrians and they must be fully integrated into the urban and rural mobility network. However, to reach a good level of safety, pedestrians must also behave according to the norms, but there is not information on the observance of rules by pedestrians, as normally it is not enforced.

[1] In Spain there is information on the percentage of dead drivers and pedestrians that were under the influence of alcohol or other drugs

2. What is unknown, but should be known.

In order to be able to determine the casualty rate for pedestrians, exposure data are needed. In all cases, but especially in relation to the most vulnerable groups of pedestrians (5 to11 years old children and elderly people of 75 years and older) information is needed on their movements, motives and other influential factors, the same way that information on car drivers is obtained in actual mobility surveys. With regard to safety statistical data, additional research is needed to fill the gaps.

Based on the different countries reports it can be concluded that the amount (as well as type) of information that is collected on pedestrians varies strongly between countries. In general, data on pedestrian exposure and safety is quite poor in the European context. The problems of many pedestrian accident reports are:

- the incompleteness of data
- under-reporting of problems
- incorrect information
- extreme difficulty of integrating accident files with other relevant data files (driver, vehicle, medical, traffic, etc.) (see also PQN Short Term Scientific Mission, 2008).

To gain more insight and knowledge on pedestrians' needs and preferences it is important to develop high quality universal standards concerning pedestrian behaviour research. Besides the need for the collection of more data, universal standardized methods would make it possible to compare situations between countries. In order to compare and integrate data, a common terminology regarding pedestrian issues should also be developed and accepted. These measures will provide a huge amount of informative data and only then will it be possible to exchange information and to learn from the best practices.

Useful data do not only concern pedestrian behaviour itself (exposure rates, accident rates) but also the locations at which the behaviour takes place. When characteristics of locations are accurately registered it is possible to relate pedestrian behaviour to environmental factors and to compare situations between countries. Eventually this could lead to specific situation-related recommendations. For example, in 2001 the Technical University of Delft (The Netherlands) developed a pedestrian-comfort guideline. Formulated recommendations are dependent on the specific location. For example, it states that streets with 5.000 pedestrians over a period of 24 hrs should have at least 2 meters of free pavement at both sides of the streets. Moreover, it is recommended that the pavement width should not only be dependent on the number of pedestrians, but also on the type of street, the pedestrian behaviour at that location (playing, shopping, strolling, etc.) and the preferred quality and comfort of the pedestrians. However, if exposure data and/or accident data are known, the situational characteristics are often unknown. Another important point is that pedestrian research should not be conducted in isolation. Behaviour of other road users should be taken into account to assess the safety and comfort of a specific location. For example, if a pavement of 2 meters is recommended, but people park their car partly on the pavement, the situation will still be uncomfortable for pedestrians. Therefore, the interaction with other road users should be taken into account when evaluating the pedestrian situation. On the other hand, not only behaviour, but also pedestrian attitudes, opinions, social values and knowledge, play an important role influencing their decisions whether to walk or not.

Nevertheless, different aspects of pedestrian variables may require different methods of measurement.

Due to the regular differences between countries (and even within countries) in regard to the research methods they apply the lessons learned are currently limited. If similar research methods were applied within and between EU countries, it could be easier to compare different variables and clear and suitable recommendations could be developed for the adjustment of environmental design. Whereas attitudes, needs, and preferences can be measured by surveys, actual behaviour on a specific location should be monitored by cameras (by using a GIS system). While exposure data can be collected in a fairly objective way, accident data are far more affected by subjective interpretation and incompleteness. Especially in the case of accident data, standardized measures and inter-observer reliability is required, which can be partly provided by recording with camera systems.

3. Conclusion - Recommendations

Completeness and Definitions of data

There were a number of issues related to the completeness of data; they are not equally defined by the different sources, so their concretion is sometimes compromised. Tables are used in different ways (and for different purposes) in different countries, and are also explained differently by placing emphasis on different features. Therefore, in a continental study such as this, it is necessary to translate them from local uses, in order to provide a global perspective.

A first pedestrians´ safety need is a good and complete data-base, made using European standards. Pedestrian conditions will not be improved as much as needed if the concerned information is not collected and analysed with standardised methods that allow comparisons between countries. To define standards for this kind of measures and data would be of great help for global studies like this.

It is also very important to address the modal shift. The modal shift is strictly related to different characteristics of cities. The blend of lower speed and a better mix of modes became an important factor in improving safety for pedestrians (Fleury, 2002; ETSC, 2005b).

Another important issue is the need for specific studies into pedestrian beliefs, interests and behaviours related to specific circumstances. There are very different attitudes towards urban space from pedestrian, on one hand, and car drivers on the other, even when they are the same people.

Best practises should include the study of all these aspects.

Campaigns have an important role to play in achieving increased awareness about risks for the most vulnerable road user and also in increasing understanding and acceptance of the need of measures to facilitate their mobility and safety.

Other examples of good practises are: the design of school guides and children circuits to show how to travel in public spaces or an innovative way of measuring pedestrian behaviour, the Spatial Metro Project (Van der Spek, 2006). This project aims to develop new ways to gain insight in pedestrian behaviour. Three different measures are used: GPS, Video observation and questionnaires. GPS data can provide detailed information on activity patterns and spatial-temporal navigation patterns. This could lead to better environmental design for pedestrians.

Some research projects have been developed keeping elderly people in mind, for example changing traffic light periods (giving more time to cross the streets) if there is someone in the zebra-crossing.

More examples can be obtained from: (TEC, 2007), (Fleury, 2002), (ETSC,2005b), Action COST C6.

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Some web pages of interest:

ADD HOME. *Add Home: Mobility management for housing areas – from car dependency to free choice* - ongoing http://www.add-home.eu

CIVITAS. *Fact sheets from various projects on sustainable, clean and energy efficient urban transport systems by implementing and evaluating an ambitious, integrated set of technology and policy based measures* - ongoing http://www.civitas-initiative.org/

COMPETENCES. Competences t*rengthening the knowledge of local management agencies in the transport field (2007)* http://www.transportlearning.net

CULTURA. *Cultura for a new mobility through mobility management, awareness measures and campaigns for changing mobility behaviour. (2005)* - ongoing http://www.mobility-cultura.net

E-ATOMIUM. *Transport and mobility training for energy agencies and local actors (2007)* –ongoing http://www.e-atomium.org/

ELTIS. *Interactive Guide to current measures* – ongoing http://www.eltis.org

EMOTIONS. *Emotions for clean urban transport* – Final report (2004) http://www.emotional-campaigns.net/

GOAL. *GOAL – Healthy without car and noise* – Final Report (2003) www.goal-graz.at

MOST. *Mobility Management Strategies for the Next Decades* – Final Report (2003) http://mo.st

MOVE *International Cluster for Mobility Management Development and Research Dissemination* ongoing - http://www.move-project.org/

STEP BY STEP. *Awareness for clean urban transport* – Final Report and fact sheets (2005) http://www.eu-stepbystep.net/

TREATISE. *Training programme for local energy agencies and actors in transport and sustainable energy actions (2007)* http://www.treatise.eu.com/

VIANOVA. *Healthy mobility and intelligent intermodality in Alpine areas* – ongoing http://www.eu-vianova.net

EPOMM. *European Platform on Mobility Management* –ongoing http://www.epommweb.org

Pedestrian risk and risk factors.

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'*If you risk nothing, you gain nothing'*
Bear Grylls

Summary

This chapter sets out with a definition of the three central terms used - accidents, exposure and risk. The conclusion reached is that there are general definitions of exposure and of risk as used in the health prevention and risk analysis fields but that in the road safety practice these terms should be defined within the context of the issue studied. In the context of this project, exposure is meant as exposure to risk. The measure of exposure is generally defined as some form of the amount of travel, either by vehicle or on foot. Risk is used to mean the probability of an accident occurring, weighted in some way by the severity of the accident's outcome. In many cases it would be better, and more neutral, to refer to rates and not to risks.

For each application, the correct exposure measure should be used. This is sometimes made impossible because the required information is not available, or has to be collected at great cost. Generally, the more aggregate the exposure measure, more indirect variables are introduced which casts shadows over the resulting risk calculations.

1. INTRODUCTION

Many safety studies involve the use of the terms accidents, exposure and risk. The impression one sometimes obtains is that the use and definition of the terms exposure and risk differ from study to study and are made in an ad-hoc fashion. This chapter explores the theoretical possibilities of the definition of exposure and risk, discusses the problems associated with the use of exposure and risk and brings a variety of examples of safety studies in which use is made of exposure and risk indicators. It will be shown that there is no general definition of exposure and of risk and that these terms should be defined within the context of the issue studied. The chapter also deals with many of the limitations that exist in the use of exposure and points out the many pitfalls that lie on the path of the correct use of the term risk in safety studies. A special effort is made to adapt these topics to the fields of pedestrian exposure and risk.

2. DEFINITIONS OF EXPOSURE AND RISK

Whereas the definition of a road accident is generally well understood in the road safety literature, the definitions of the concepts exposure and risk are much less well-defined. An accident is generally defined, in this context, as an event in which at least one motor-vehicle was involved, that occurred on a public road and which resulted in injury. This definition is used because in most countries computerised systems exist for the recording of such accidents. This is also the definition mostly used by police forces to record an accident. Other road accidents are kept in other data-bases or are unrecorded. National differences exist in the definitions of accidents that are recorded by the police, those that are entered into the statistical database on accidents with casualties and definitions of the various degrees of severity of injury. International data bases do not always account for such differences in definitions. The international accident data base IRTAD, maintained by the Organisation for Economic Development (OECD), makes a concerted effort to report on these differences and account for them where possible.

2.1. Under-reporting of accidents

The under-reporting of accidents has been covered in other parts of this project and will not be dealt with in detail in this chapter. In connection with pedestrian accidents and safety though, a number of points need pointing out. Together with bicycle accidents, pedestrian accidents are significantly under-represented in the official national police data-bases. With bicycle accidents this has much to do with the fact that in most countries many bicycle accidents occur to children and near the home. In those cases the first priority is to get the child to medical care and less attention is paid to notifying the police. Another point is related to the fact that only part of these accidents is recorded as traffic accidents. A few countries, including the Netherlands and Sweden, have collected statistics on the types of pedestrian accidents, including falls. As reported by Feypell et al (2010), in the Netherlands, the average annual number of pedestrian casualties during 2003-2007 was 55,000. Of these, only 5,000 were traffic accidents and as such would appear in the official police statistics. For bicyclists the comparable numbers were 68,000, of which 14,500 were traffic accidents (Methorst et al, 2009). A Swedish study from 2009, (Larsson, 2009), presented similar results. Over the years 1998-2007 out of a total of 26,089 pedestrian casualties, 6,433 were reported as traffic casualties. The problem with this partial reporting is that pedestrian safety does not receive its proper attention and share in investments when decisions are based on levels of safety and on economic analyses. The same study, by Methorst et al (2009), also showed that in the Netherlands almost 40 percent of all societal costs associated with travel accidents are related to bicycle and pedestrian accidents.

Although many shortcomings can be identified with regards to this definition of an accident at least we are talking about a recordable event which is to a certain degree exact. As to exposure and risk, on the other hand, we first have to agree on a definition and then it remains to be seen if the accepted notions are quantifiable and reasonably exact.

2.3. Definition of exposure

In the context of this chapter, exposure is meant as exposure to risk. To what extent are certain segments of the population likely to be involved in an accident? The measure of exposure is generally defined as some form of the amount of travel, either by vehicle or on foot. Once the amount of travel is known for certain activities, or road users, and if we know the number of crashes that are associated with that activity or population, the associated risk can be calculated. Risk assessments can be used to improve transport safety and in determining public health priorities. ….”*The various ways of measuring the volume of travel are referred to collectively as ‘exposure data’ because they measure traveller’s exposure to the risk of death or injury*”…. (ETSC, 1999).

2.4. Definitions of risk

According to the Oxford Dictionary, risk is a “hazard, chance of bad consequences, loss etc., exposure to mischance”. Collins Dictionary describes risk as “a possibility that something unpleasant or undesirable might happen; something that you do which might have unpleasant or undesirable results”. In the field of road safety the concept of risk is used as a way to quantify the level of road safety relative to the amount of exposure as opposed to the absolute level of safety as measured by the absolute number of accidents or casualties. For our purposes, risk will be used to mean the probability of an accident occurring. Such a definition was proposed in Hauer (1982).

One element which might usefully be added to the definition of risk as a probability and that is taking into account the severity of the outcome of an event. This distinction is proposed in Haight (1986). The quantitative approach makes it possible to calculate the expected losses during a given period of time, usually expressed in terms of fatalities, casualties and/or material damage. In the field of road safety a similar approach is generally used. This approach is generally preferred over the qualitative approach.

The popular perception associates risk with both the probability of a hazardous event for someone involved in a certain activity and with the severity of the outcome. Problems generally arise when one tries to compare situations with both different probabilities and different consequences, given an accident occurs. For these reasons it is in many situations preferable to talk about accident rates (or casualty rates) instead of risk. When comparing accident rates it is assumed we are talking about situations with similar severities of outcome, otherwise the situations should not be compared.

2.5. The size of the safety problem in terms of risk and exposure

Having defined risk and exposure it is now possible to define safety and the size of the safety problem in those terms. *Figure 1* (Rumar, 1999) defines the safety problem - I as a function of exposure, accident risk and injury risk:

I = E x A/E x I/A , where

I is the number of people injured

E is exposure

A/E is the probability of an accident (accident risk)

I/A is the probability of being injured in an accident (injury risk)

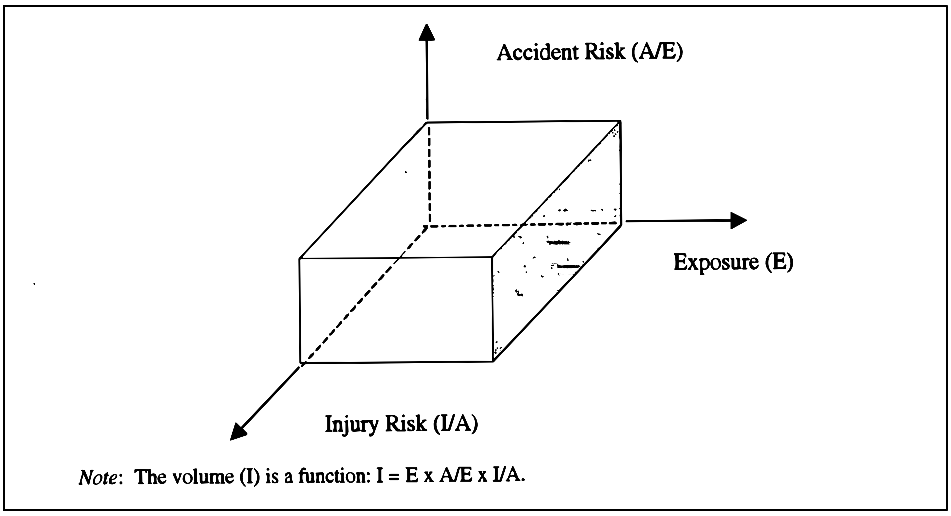

Figure 1 The safety problem (human injury) illustrated by the volume of the box. From: Rumar, 1999.

From this definition it becomes clear that countermeasures to improve road safety can come from activities along any one of the three axes. One can think of measures that reduce exposure, measures that reduce the risk of an accident and measures that reduce the risk of injury. It is also possible to bring the time trend element into consideration. The absolute size of the safety problem, expressed in either the number of accidents or the number of casualties (SAFETY) of a certain severity results from multiplying the degree of risk, which has a trend with the exposure, which also has a trend element expressed as:

SAFETY(severity) = **RISK**(trend) x **EXPOSURE**(trend)

3. QUANTIFYING EXPOSURE AND RISK

3.1. Exposure measurement

Exposure is generally expressed in a form related to the amount of travel. In most countries traffic data (volumes) are counted for traffic engineering purposes but few countries have systems of counting traffic volumes that enable comprehensive measurement of volumes on various parts of the road system, segregated by type of road user. Some countries have such systems for parts of the road system - motorways, main rural roads, major intersections, etc. Still other countries have only approximate estimates of the amount of travel conducted on the basis of the known fuel consumption in the country.

For the calculation of exposure by different groups of road users: car drivers, car passengers, public transport passengers, cyclists and pedestrians the information from traffic counts does not suffice. The additional information is generally obtained from national travel surveys which are conducted in many countries with the frequency of between 5-10 years.

The Netherlands is one of few countries that conduct travel surveys which include travel on foot and by bicycle. In the most recently published data from the 2008 travel survey (RWS, 2008), interesting data on pedestrian exposure come to light. In 2007, out of the total annual travel distance by all modes of transport, 2 percent was on foot and 7.6 percent was by bicycle. However, in terms of number of trips, the percentages were 22.3 on foot and 24.2 percent by bicycle. The average length per trip was about 10 kms. This shows that, depending on which type of exposure one chooses, pedestrian trips make up a considerable proportion of the total.

A limited travel survey carried out in one metropolitan area in Israel in 1996, included information on travel on foot and by bicycle (Haifa, 1998). The area includes a population of about 500,000, out of the total population of 7 million in Israel. Trips on foot composed 18 percent of the total trips, while bicycle trips made up 1 percent. The region is mostly very hilly terrain, which would explain the low percentage of bicycle trips.

Cabello et.al (2010), provide information on travel surveys in 13 countries in Europe. However no information is provided on breakdown by mode and therefore it is impossible to know whether pedestrian trips are included and what percentage of trips they constitute. Another table in the same publication does provide the mode split between modes, presumably by number of trips. The percentage walking varies from 45 percent in Switzerland and 22 percent in the Netherlands, to 5-9 percent in Australia, Canada and the US. Bicycle travel adds another 1-15 percent of trips (15 percent in Denmark)

Data from different sources can be combined to calculate disaggregate exposure estimates for different population subgroups.

At this stage it can be said that for each application, the correct exposure measure should be used. This is sometimes made impossible because the required information is not available, or has to be collected at great cost. Generally, the more aggregate the exposure measure, the more intervening variables are introduced that cast shadows over the resulting risk calculations.

3.2. Quantifying risk by hours of exposure

A number of authors have suggested that it is useful to calculate risk by hours of exposure to a certain activity (Evans, 1993; ETSC, 1999; Wesemann et al., 1998). In the case of transport the most widely used measure of exposure is distance travelled, but it is obvious that even for transport the speed at which such travel is conducted might influence the risk. Speeds for various transport modes (walking, cycling, motorised transport) are widely different and therefore it has been suggested to normalise exposure (vehicle kms travelled) by multiplying by speed thereby obtaining a risk measure which is expressed as accidents or casualties per hour of exposure. The Dutch travel survey mentioned earlier (RWS, 2008), shows that In terms of time spent on travelling 21 percent was spent walking and 17.3 percent by bicycle. These percentages are considerably greater than the percentages in terms of number of trips and in terms of distance travelled.

Collins (1990) provides details on accidental fatality rates for various activities in transport and other fields of activity per passenger-hour and per passenger-km travelled (*Table 1*).

Table 1 Accidental fatality rates for transport and other activities. In Evans (1993), from Collins (1990).

	Fatalities per 100M passenger-hours	Fatalities per 100M passenger-km
Passenger travel by		
Bus or coach	1.4	0.06
Rail	6.0	0.1
Car	12.4	0.4
Water	16.0	0.8
Air	20.0	0.04
Foot	27.0	7.0
Pedal cycle	64.0	4.6
Two wheel motor vehicle	342.0	11.4
Employment		
All work	0.9	
Banking and financing	0.17	
Chemical industry	1.1	
Construction work	4.9	
All railway work	5.6	
Extraction of ores	13.0	
Being at home		
All ages	2.6	
People under 65	1.0	
People 65 and over	11.5	

It can be seen that travel is a relatively high risk activity compared with such other activities as being at work (most kinds of work) and being at home. Large differences can be observed in the risk associated with the various travel modes, with bus and rail travel being relatively safe both in terms of vehicle-kms travelled and hours exposed, air travel being relatively safe in terms of kms travelled but not in terms of hours of travel, due to the high speeds of travel. Travel by vulnerable road users, on foot, pedal cycle and motor-cycle being relatively unsafe both in terms of hours and kms of exposure.

Koornstra in ETSC (1999) also presents a risk comparison for various modes of travel aggregated for the whole of the EU (*Table 2*).

Taking bus and coach travel as a normative unity, it can be seen that risk expressed in terms of person-kms travelled is 10 times greater for cars and 100-200 times greater for the vulnerable modes (foot, cycle and motor-cycle/moped), with motor-cycles clearly being the most hazardous. Train and plane travel are also relatively safe. Looking at the same data with risk expressed in terms of person-hours of travel does not change the picture greatly. Foot and cycle travel become slightly less hazardous, because of the low speeds of these modes, whereas air travel becomes significantly more hazardous because of the high speeds of travel (hence the small number of hours per km of travel. Section 5 of the paper will discuss in more detail the usefulness of making such comparisons.

Table 2 Fatality risks over distance and time for travel modes in the EU. Source: ETSC, 1999. Normalised rates calculated and added by the authors.

Travel mode		10^8 person km		10^8 person hours	
		absolute	normalised	Absolute	normalised
ROAD	Total	1.1	13.8	33	16.5
	BUS/COACH	0.08	1	2	1
	CAR	0.8	10	30	15
	FOOT	7.5	93.8	30	15
	CYCLE	6.3	78.8	90	45
	M/C, MOPED	16.0	200	500	250
TRAINS		0.04	0.5	2	1
FERRIES		0.33	4.2	10.5	5.3
PLANES		0.08	1.0	36.5	18.3

3.3. The relevant measures of exposure and risk

In the context of risk calculations it is important to define and select the correct measure of exposure. The selection of what should serve as a “correct” measure of exposure will depend mainly on the intended use. A large number of exposure variables can be selected, each suitable to a specific problem at hand. In many cases, because of the lack of detailed enough data, or the lack of accurate data it is not possible to select the correct measure of exposure to suit a particular issue.

Aggregate measures of exposure and risk

In international comparisons and for trend studies on a national level, in many cases, the number of inhabitants or the number of vehicles are selected as the available exposure measure. Risk calculated as the number of fatalities divided by the number of inhabitants can be considered as a measure of mortality, i.e. what is the chance of death per unit population? The advantage of this risk measure is that it uses fairly reliable data which are generally widely available. It is therefore possible to conduct such international comparisons. The same cannot be said when attempting to calculate the risk of injury. Large differences exist in the reporting procedures of road casualties, depending on the reporting procedures in each country. Various levels of under-reporting of accidents and casualties exist in different countries (Nilsson, 1997). Defining the risk as the number of fatalities (or casualties) per number of vehicles can be seen as a proxy to the risk of travel. In this context the number of vehicles is selected as a proxy to the number of vehicle-kilometres travelled which is a variable that is much more difficult to obtain reliably in many countries. Obviously, if a certain type of vehicle is considered, one should use the relevant numbers of fatalities and vehicles.

One of the complications associated with this type of comparison is that the two risk measures - fatality per unit population and fatality per unit vehicles - behave very differently over time when comparing different countries. It should also be remembered that both measures are very gross, not differentiating between different segments of the population (by age group, sex, urban or rural, etc.) and different types of vehicles. It is generally found that trends relating to the number of vehicles are a reasonable proxy to the number of vehicle-kms of travel. Many studies exist in the literature reporting on risk comparisons conducted with these measures of exposure.

Such comparisons are useful in obtaining a very coarse picture of the safety situation, without contributing much to the understanding of the differences found between countries or changes over the years. For such an understanding risk calculations on a much more detailed level should be conducted.

Table 3 presents some examples of risk indicators on an aggregate level and their availability in international databases as well as the US database on fatal accidents (FARS).

Table 3 Available risk indicators. From: DUMAS, 1998.

	WHO	IRF	ECMT	IRTAD	EURO-STAT	FARS
Accidents/inhabitants				+		
Accidents/VehKm		+		+		
Accidents/VehKm I/O built-up areas				+		
Accidents/VehKm by road class				+		
Killed/inhabitants	+		+	+	+	+
Killed/inhabitants by age group	+			+	+	+
Killed/inhabitants by age group & sex	+				+	+
Killed/licensed drivers						+
Killed/million vehicles			+			+
Killed/million road users by road user type			+			
Killed/VehKm		+		+		+
Killed/VehKm I/O built-up areas				+		
Killed/VehKm by road class				+		
Injured/inhabitants				+	+	+
Injured/inhabitants by age group				+	+	+
Injured/inhabitants by age group & sex					+	+
Injured/ licensed drivers						+
Injured/million vehicles						+
Injured/Vehkm				+		
Injured/VehKm I/O built-up areas		+		+		
Injured/VehKm by road class				+		

A detailed description of pedestrian fatality risk rates in many European countries, relying on the CARE and IRTAD databases, is provided in Papadimitiou (2009). Average pedestrian fatality rates, for the year 2006 are provided, based on data from 25 countries, with a breakdown of data by daytime/ night-time, by month, by age and per country.

Traffic volume as a measure of exposure
Some form of traffic flow is generally taken as the measure of exposure when calculating risk on a certain part of the road network or for a certain type of vehicle. The most frequently used measure of exposure is the number of vehicle-kms travelled. Risk levels on various parts of the road network or at various types of intersections are deduced from the ratio between accidents, casualties or fatalities and the relevant exposure measure related to traffic flow.

Problems with quantifying exposure
Most countries collect data on the amount of traffic in a systematic way. These would include almost certainly traffic count data that are needed for the decision on building a new road, widening an existing one or re-designing an intersection. Some countries also have aggregated traffic counts for some parts of the road network (generally the major roads). Few countries have aggregated traffic counts which can be converted to reliable amounts of vehicle-kms travelled, but sub-divided for various parts of the urban and non-urban network. When such traffic count censuses are available, they can give us the necessary information on exposure, by type of road and type of vehicle from which detailed risks can be calculated. In many other countries the alternative to a traffic count census, is by measuring fuel consumption on a national scale and from that to calculate the amount of travel. Such calculations are open to many different sources of error and generally lead to only rough estimates of the amount of vehicle-kms travelled. Such estimates can also not be sub-divided into types of road. These are the major difficulties in obtaining exposure measures on the National scale. For more detailed studies, relating to a specific study, it is generally required to collect special and dedicated exposure data. This is an expensive process and is not always feasible.

4. SOME ISSUES ASSOCIATED WITH THE USE OF EXPOSURE AND RISK

4.1. The desire to assess risk levels and to strive towards equal risks

According to a recent ETSC report it is important to collect exposure data for the use in risk assessments that can be used to improve transport safety. ETSC defines the following ways to conduct such assessments: "

- *monitoring casualty trends and evaluating policies which have been introduced to improve safety, in order to provide a sound basis for developing new policies*
- *comparing the levels of risk of different types of travel (for example by transport environment or transport mode)*
- *setting priorities, that is identifying those transport situations with high levels of risk in order to formulate policies and concentrate resources to reduce risk levels, especially for high severity crashes"* (ETSC,1999*)*

A basic assumption is that it is desirable to strive for equal risk to various categories of road users, including the vulnerable road user, in order to achieve equal risk on various categories of roads. Unequal risks on different categories of roads and for different categories of road users do however exist and it is almost impossible to envisage that such risks can be made equal at a reasonable economic cost. Similarly, equal risks in various parts of the country, municipalities, regions, provinces are almost certainly unachievable at a reasonable economic cost. Even the calculation of such risks is almost impossible because of the lack of reliable and detailed exposure data on the provincial and municipal levels.

4.2. Over-representation and risk

Much of the work on risk in safety studies seems to stem from accepted and established procedures taken from the field of epidemiology as practiced in medical and health related studies. From epidemiology a logic is adopted which seems to be the basis for the use of exposure and the calculation of risk (Hauer, 1995). It is the search for over-representation in various populations under study that lies at the base of this approach. Searching for over-representation seems to suggest the following line of thought and action:

[**deviation-from-normal**] leads to [**clue-to-cause**] leads to [**clue-to-remedy**]

One underlying requirement in this chain of thought is a further assumption which is the *"presumption-of-sameness-except-for-the-suspected-cause"* (Hauer, 1995; Ekman, 1995). In medical studies, this might well be a legitimate assumption in many cases. Hauer (1995) brings the example of John Snow, who established in 1854 that people who live in the same districts, but whose water is supplied by different companies, had vastly different incidences of cholera, many years before the discovery of the vibrio of cholera. From this Snow could infer what the cause of the cholera epidemic was and what the remedy might be.

In transportation safety studies, the presumption of sameness is hardly ever the case. In the comparison of accident and fatality rates for different modes of transport (air travel vs. road travel), rates for different modes of road transport (lorries, cars, motor-cycles, etc.) it is definitely wrong to assume sameness. By itself, over-representation in accidents or fatalities has no discernable logical link to funding, programming, decision or action. The decision-making process should be concerned about establishing the relevant facts, adopt a set of proven counter-measures and base the decision on the cost effectiveness of the preferred solution.

One subject that has received a lot of attention in recent years is the issue of older drivers and their "over-representation" in accidents or their higher-than-average risk (Hauer,1995). The motivation behind this seems to be related to the fact that in many countries society is ageing, that older drivers are over-represented in accidents or in fatal accidents and that, therefore, something should be done about this. Indeed, when the rate is calculated "per mile driven", drivers in the 75+ group have trice the rate of drivers in the 35-40 years age group. But when looking at the numbers, while 1486 drivers who were 75-80 years old died in the US in 1986, 3203 drivers in the 30-35 years age group died in the same year. It seems perfectly clear that the quest for counter-measures should be driven by improving the safety record for the older driver. This could be done by adapting the highway infrastructure to better suit the older driver, or by other means that could be implemented in a cost-effective manner.

4.3. Pedestrian risk and exposure while crossing the road

While for aggregate purposes generally risk indices such as pedestrians injured or killed per thousand inhabitants, or per distance travelled, are used, once we come to evaluate the safety of different types of crossing facilities, other types of risk have to be defined. It is first necessary to define what exposure measure will be used. The large majority of pedestrians are injured or killed while crossing the road. A measure of exposure is thus needed which quantifies this manoeuvre. There is, as yet, no agreement in the literature over the correct measure of exposure while crossing the road. Hakkert and Bar Ziv (1981) developed a model which accounts for both the volume of crossing pedestrians and the traffic volume passing the street.

To obtain the correct measure of risk they develop a model which relates the number of pedestrian crossing accidents to the product of both flows, raised to a certain power. On the basis of such models, the safety performance of various types of crossings can be compared.

Ivan et.al (2000), develop models for pedestrian exposure in rural areas of Connecticut, related to factors such as population density, sidewalk characteristics, number of lanes, area type, signal type and median household income. They further develop models relating crash probabilities depending on site characteristics.

4.4. National safety levels and targets

National road safety targets are generally set in terms of numbers of accidents, casualties and fatalities, or percentage reductions to be achieved. This has been the case in The United Kingdom, The Netherlands, Sweden, Australia and many other countries. There are several reasons for this approach. First, in terms of the impact on the population, it is the absolute numbers that count. Focusing on risk might show a reduction in risk which is the result of an increase in exposure which is greater than the increase in accidents or fatalities. This would thus miss the point of achieving an absolute reduction in the number of casualties or fatalities. Targets based on risk levels are also undesirable because of the fact that risk levels in general tend to decrease over time because of the whole range of road safety activities and because of inherent changes in the traffic volumes and composition. Once having set target in terms of numbers, it is however possible to use risk levels to control for changes in certain areas, regions or municipalities. If the number of casualties or fatalities in a region is increasing faster than average, it is worthwhile looking at the exposure and risk to study the differences before reaching conclusions.

When dealing with trend analyses of road safety phenomena, it might be possible to work with the raw accident and injury data for short-term prognosis. On the basis of past trends, when dealing with before-after evaluations, it is generally possible to apply time series models and intervention-type models to predict the short-term effect of a counter-measure using accident and casualty data. In the case of long-term projections, 5-10 years onwards, it is generally necessary to first estimate the underlying trend in exposure data before making a prognosis.

4.5. What is an acceptable level of risk?

In a general way, the question of what is an acceptable level of risk in road traffic is virtually impossible to answer. Any limit other than zero risk is arbitrary and disputable. Zero risk, however, may be a valid ambition in theory, but hardly possible, if at all, to realise in practice. Furthermore, when talking about the acceptable level of risk a distinction must be made between various types of risk, for example individual risk versus societal risk and voluntary risk versus compulsory risk. What risk level is acceptable for an individual road user when he or she makes a particular trip with a particular transport mode? What is the acceptable risk level for the society as a whole, in other words how many accidents or casualties per year per unit of exposure are we as a society willing to accept at public roads? And is it reasonable to accept higher risks when taken on a voluntary basis (e.g. a recreational bicycle tour) than when taken on a compulsory basis (e.g. for professional drivers or home-work travel). Some of these questions are answered by society through actions that government and local agencies take on the programs and budgets devoted to road safety. There are no absolute and correct levels as becomes obvious when looking at the actions taken in different countries, which result in them having different levels of risk and safety. At the individual level there are also no correct and absolute answers. Individual risk varies from person to person, from task to task and can even vary for the same person depending on mood, time-pressure and whether the risk is voluntary or compulsory.

One could also make the distinction between risks involved as a passenger or driver of a certain type of vehicle and the risks associated with the use of such a vehicle but to other road-users. In this way, lorries are a very safe means of transport to their occupants, because very few fatalities occur to drivers and passengers of lorries, both in absolute numbers and expressed as fatalities per vehicle-km travelled, but they are involved in a proportion of fatal accidents which is considerably larger than their share in vehicle-kms driven. The same is the case for buses. Cars are also becoming safer and safer for their occupants, because that is where most technological innovation and development have been applied - US and European safety regulations, seat belts, air bags, etc. Thus the risk of being injured or killed per vehicle-km travelled continually decreases. However, the issue of injuries and fatalities caused by these vehicles to the vulnerable road-user are only now being addressed and still there are few technological developments that are effective.

Similarly, in particular relevant for the transport of dangerous goods, one could make a distinction between the accident or injury risk for road users and the risk for third parties, for example for those living in the area and being exposed to toxic chemicals following a road accident with a dangerous goods truck. In the Netherlands this distinction is made in the external safety report which is required for the dangerous goods transport industry. As an indicative value, the third party risk in this type of industry should not exceed 10^{-4} for events resulting in 10 victims and 10^{-6} for events resulting in 100 victims per year per kilometre route (RIVM, 1998).

5. CONCLUSIONS

The chapter sets out with a definition of the three central terms used - accidents, exposure and risk. The conclusion reached is that there are general definitions of exposure and of risk as used in the health prevention and risk analysis fields but that in the road safety practice these terms should be defined within the context of the issue studied. In the context of this study, exposure is meant as exposure to risk. The measure of exposure is generally defined as some form of the amount of travel, either by vehicle or on foot. Risk is used to mean the probability of an accident occurring, weighted in some way by the severity of the accident's outcome. In many cases it would be better, and more neutral, to refer to rates and not to risks.

For each application, the correct exposure measure should be used. This is sometimes made impossible because the required information is not available, or has to be collected at great cost. Generally, the more aggregate the exposure measure, more indirect variables are introduced which casts shadows over the resulting risk calculations.

In the case of transport, the most widely used measure of exposure is the amount of travel for each travel mode. In some cases, useful additional insight is provided by taking into account the speed of travel, in which case exposure is expressed as the amount of time spent in the traffic system. Due to the very different conditions and circumstances, it is felt of little use to extend this comparison of risk per unit of time to other activities beyond the field of transport. Within the field of transport, modes can usefully be compared, up to a certain point, by risk per unit of travel or per unit of time. Taking bus and coach travel as a normative unity, it was shown that risk expressed in terms of person-kms travelled is 10 times greater for cars and 100-200 times greater for the vulnerable modes (foot, cycle and motor-cycle), with motor-cycles clearly being the most hazardous. Train and plane travel are also relatively safe. Looking at the same data with risk expressed in terms of person-hours of travel does not change the picture greatly. Foot and cycle travel become slightly less hazardous, because of the low speeds of these modes, whereas air travel becomes significantly more hazardous because of the high speeds of travel (hence the small number of hours per km of travel).

The lack of detailed and high quality exposure data is one of the reasons that in many cases international comparisons are conducted on a per capita or per vehicle basis and deal mostly with fatalities because of the inaccuracy of injury reporting.

On road sections, the number of vehicle-kms is generally accepted as the relevant measure of exposure. At intersections, the correct measure of exposure is not that obvious. The product of the daily crossing flows and the sum of the products of the hourly crossing flows have been used as exposure measures in many accident studies. In a way, which is fairly similar to the discussion of risk and exposure at intersections, one can consider the definition of risk to pedestrians. In this manner one obtains a measure of exposure which is the product of the traffic flow and the crossing number of pedestrians. The risk is then defined by dividing the annual number of pedestrian accidents by the exposure.

One of the contexts in which risk is used, is in comparing risks between different parts of the transport system, different transport modes or even different activities outside the field of transport. The desire is to make various activities exposed to equal risks, so as to make them ”fair”. It is concluded that the desire for equal risks in various segments of the transportation system is not practical. It is more useful to search for ways to make each segment of the transport system as safe as possible, keeping cost-effectiveness considerations into account.

In the context of national levels of safety, targets are generally set in numbers of casualties and fatalities. This seems preferable over setting targets as risks, which then can become intertwined with changes in exposure (mobility), which affect the risk. When however comparing risks and safety among different transport modes, different regions of a country or different countries it seems that comparisons will have to be made on the basis of accidents and fatalities per vehicle-km travelled and in some cases, per passenger-hour travelled. In other cases a risk per passenger trip travelled may be more meaningful.

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Pedestrian safety data[1]

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Summary

This chapter is assessing the magnitude of pedestrian safety in urban spaces. It addresses both non traffic accidents (i.e. a pedestrian falling) and traffic accidents (a pedestrian hit by a vehicle), thus giving a more complete image of accidents that happen to pedestrians.

The paper starts with describing relevant definitions of pedestrian accidents. Next the issue of underreporting is discussed.

The third section highlights the fact that non traffic accidents constitute an important part of the safety problem of pedestrian, which is often not reported and not well known. Only a very limited number of countries have gathered data on this issue. It is found that, compared to traffic accidents, there are 3 to 9 times as many pedestrians severely injured (admitted to hospital). Around 80% of pedestrian severe injuries are due to falling and, since the impact force when falling is lower than the impact of a moving vehicle, the count for pedestrian fatalities is substantially lower: 1 of every 3 pedestrian fatalities were due to falling.
Most (more than 85%) of the accidents happen in urban areas on sidewalks, roadways and cycle ways.

The vast majority of all victims are children (0 – 14 years) or elderly. The majority of severely injured the victims are elderly. Because of ageing of the population, it can be expected that this constitutes a growing problem.

In countries with marked winter conditions ice and snow are the major factor in falls; in warmer countries unevenness, potholes and rutting can be expected to be the major causal factor for falls. Maintenance (slippery leaves, rubbish on the street) is a third factor.

With regard to costs of pedestrian falls very little data exist. An indicative Dutch study shows that 16% of all societal costs of travel accidents are related to pedestrian falls, amounting to 1.4 billion Euros of the total of 8.9 billion Euros of travel accident costs (incl. Falls).

[1] This article was written for the OECD/ITF report on Pedestrian Safety, Urban Space and Health. A shorter version of this article is included in that report.

The fourth section focuses on collision of pedestrians with motorised traffic and describes various accident scenarios. The section starts with a macroscopic pedestrian traffic safety analysis in OECD/ITF countries. Internationally 17.8% of all fatalities are pedestrians. Fatality rates vary very much. In the safest countries the number of fatalities is as low as 3.8 fatality per 100,000 inhabitants, while in un-safe countries the score higher than 14 per 100.000 inhabitants (i.e. Poland). The number of fatalities shows a downward trend.

Contrary to other road users, most of the pedestrian traffic fatalities are due to accidents in urban areas. Internationally some 35% of all pedestrian fatalities had their accident in a rural situation.

Like in falls, there is an age relation. The average risk amongst the elderly is 25 fatalities per million inhabitants. For children the average risk is 5 fatalities per million in habitants. There is however a huge spread in scores per country.

The car is the dominant opponent in accidents, but the involvement per billion vehicle kilometres shows a different picture. Motorcycles and buses are over-represented. Speed is the most important causation factor.

In general 4 accident types (scenarios) are distinguished: accidents during crossing (more than 70% of the accidents), accident on pavement, out of crossing, accidents where pedestrians are collateral damage and 'particular context.

1. What is a pedestrian accident

A **pedestrian** is any person involved in an accident who was not at the time of the accident riding in or on a motor vehicle, railway train, streetcar or animal-drawn or other vehicle, or on a pedal cycle or animal. It includes persons changing tyre of vehicle, making adjustment to motor of vehicle, on foot. It also includes user of a pedestrian conveyance such as baby carriage, ice-skates, perambulator, push-cart, push-chair, roller-skates, scooter, skateboard, skis, sled, wheelchair (powered).

A **traffic accident** with bodily impact is defined by the Vienna Convention as follows[2]:

> "*Accidents which occurred or originated on a way or street open to public traffic; which resulted in one or more persons being killed or injured and in which at least one moving vehicle was involved. These accidents therefore include collisions between vehicles, between vehicles and pedestrians, and between vehicles and animals or stationary objects. Single vehicle accidents, in which one vehicle alone (and no other road user) was involved, are included.*"

The problem of this definition is that pedestrians without a counterpart are excluded, as no vehicle was involved.

Falls in pedestrians (FiP): The term "Falls in Pedestrians (FiP)" means pedestrian falling and injuring themselves in public areas without having a collision involving a vehicle (accidents due to falls in pedestrians in home and sport activity are excluded).

[2] (01) This definition is almost followed by EU25. However national definitions vary slightly e.g. by defining vehicles as motorised, including material damage or any event causing injuries or fatalities on public areas, not being limited to involving vehicles.
(02) Public Road Administration (ed.). IRTAD special report on "under–reporting of road traffic accidents recorded by the police at the international level", Norway 1994.

Public area: The public area includes pavements, pedestrian malls, cycle ways, motorways, public roads outside urban areas, public roads inside urban areas, unspecified roads, bus stations, railway areas, freight terminals, quays, track ways and vehicle access routes in docks, transport areas.

2. The issue of underreporting

Data on non-fatal and fatal casualties, based on police reports, provide detailed information about accidents involving a (mostly moving motorised) vehicle. However, while police data on fatalities are rather accurate, injury accidents are largely underreported (IRTAD, 2006).
In addition, falls of pedestrians e.g. because of bad road conditions are rarely reported as they are excluded from the international agreed definition on injury accident:

"*Any accident involving at least one road vehicle in motion on a public road or private road to which the public has right of access, resulting in at least one injured or killed person*"[3].

Therefore pedestrians injured in accident not involving a motor vehicle, are not reported by the police. They are at best recorded in hospital records.

In Western Australia, hospital admission and police crash report data spanning the 15-month period October 1987-December 1988 were linked to produce a Road Injury Database (Rosman and Knuiman, 1994). Police crash reports were identified for 69 percent of the pedestrians who had been admitted to a hospital for treatment of injuries resulting from (reportable) collisions with motor vehicles.

In a survey of hospitals carried out nationwide in Australia in 1990-1991, pedestrians comprise 15 percent of all admissions for road traffic injuries (O'Connor and KPMG Peat Marwick, 1993). For this sample of hospital admissions, 94 percent of the pedestrians were injured in motor vehicle traffic accidents and 5 percent in motor vehicle non-traffic accidents, with just over 1 percent falling into a category of "other" road vehicle accidents. The authors of the report note that minor injuries requiring only emergency department treatment were especially likely to be underreported by police, with over twice as many cases appearing on emergency department files as on police files.

European and British studies add to the range of findings. Maas and Harris (1984) reported ratios of .78 for numbers of police-reported versus hospital-reported pedestrian injuries, in The Netherlands during the early 1970s. In a subsequent article, Harris (1990) reported that these ratios had declined to less than .70 percent by the late 1980s. Using information gathered from a national telephone survey that was restricted to "reportable" accidents, but which included all levels of injury severity, not just hospital cases, Harris documented ratios of .25 for pedestrians.

In Stutts & Hunter (1999) study, 1,443 injured pedestrians were identified in hospital emergency data, including 36 % injured in collisions with motor vehicles, and 64 % injured in transportation-related falls or pedestrian-only events. Information on the location of the injury event with respect to the roadway was available for 1,345 cases (93 % of the total). Of these, 47 % occurred on the roadway, and 53 % in a non-roadway location. As expected, the large majority (88 %) of pedestrian-motor vehicle collisions occurred on the roadway; however,

[3] International Transport Forum, EUROSTAT, UNECE (2009). *Glossary for transport statistics. 4th Edition. http://www.internationaltransportforum.org/Pub/pdf/09GloStat.pdf*

nearly four out of every five pedestrian-only events occurred on sidewalks, in parking lots, or in other non-roadway locations.

From the point of view of public health, there is no sufficient reporting on non-collision accidents, especially those involving pedestrians (Hvoslef, 2005) [4] (04) and the vast number of injuries due to falls on public roads has scarcely been acknowledged (Kisser et al, 2005)[5]) Usually fewer coding variables, in order to register external causes of injury events, are used in death certificates conducted by each Member State than provided by the coding manual of the International Classification of Diseases Version 10 (ICD-10) of the World Health Organisation (WHO) (e.g. only three of four coding digits). Thus a correction of the general underreporting of fatal vulnerable road users injuries and an analysis of injury types, modes of transport, type of road or day time is not feasible at the moment. As specific coding variables are missing to connect the location “public road” with falls of pedestrians, the analysis of their fatal injuries on public roads is also not possible.

Although injured pedestrians are included in the data, the lack of a common definition of serious and slight injuries does not allow for conclusions to be drawn. In recent studies (Broughton et al. 2007; Amoros et al.2008), it is proposed that injury severity should be assessed on the basis of medical information, such as the MAIS (Maximum Abbreviated Injury Scale) and the length of stay at the hospital, which can only be obtained through hospital records. However, this data is seldom available or accessible, even at national level. Within this context, the European Injury Database (IDB), hosted by the European Commission includes accident and injury data from selected emergency departments of Member State hospitals, providing data such as routine causes of death statistics, hospital discharge registers and data sources specific to injury areas, including road accidents and accidents at work. The IDB is the only data source in the EU that contains standardised cross-national medical data; however it is focused on home and leisure accidents in Europe, most likely not including a considerable percentage of traffic accidents.

Such records are also often used for the estimation of the degree of injury under-reporting, i.e. the estimation of the actual number of casualties of a given level of severity, in relation to the respective number of casualties recorded by the Police. Nevertheless, under-reporting can be fully addressed only once standardized definitions are applied and medical data are exploited. Given the additional particular issues related to pedestrian injury data, the estimation of under-reporting of pedestrian accidents and injuries is expected to be even more complicated.

A recent European pilot study (Broughton et al. 2007) estimated the magnitude of underreporting of pedestrian injuries in Europe. In this study, Police records were linked to hospital records in six European countries (or regions within countries) and correction factors (under-reporting coefficients) were calculated for the number of injuries recorded by the Police, in order to obtain the actual number of pedestrian injuries (see Figure 1). It was found that, overall, pedestrian injuries are less under-reported than the national average, but still present important degree of under-reporting. Moreover, in some countries the problem is more pronounced as regards slight injuries (namely in CZ, FR, GR), whereas in other countries serious injuries are more under-reported (NL, UK).

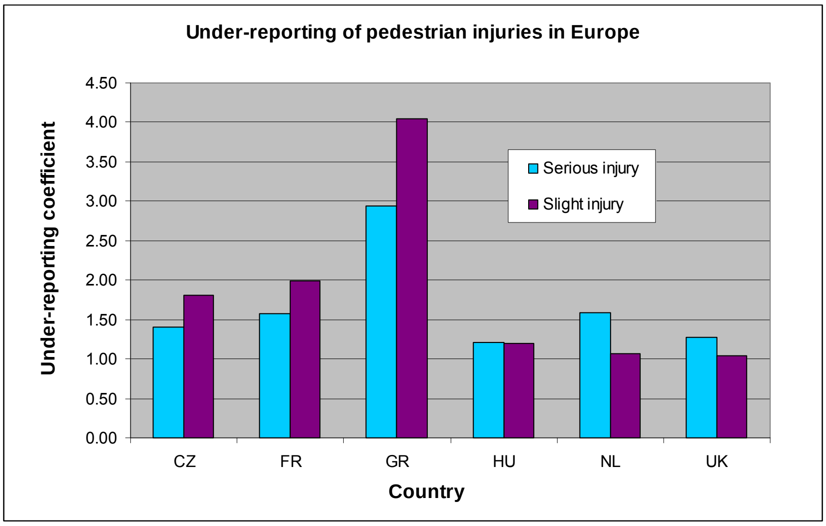
A final issue that needs to be kept in mind when examining international pedestrian safety data is the lack of respective mobility / exposure data, which would allow for risk estimates.

[4] (04) cp. Hvoslef, H.. Under-Reporting of road traffic accidents recorded by the police, at the national level, Operational Committee of IRTAD and Norwegian Public Roads Administration, Oslo 1994 in: Kisser, R., Kormer, C., Sengolge. M.. Actions for the public health sector to improve road traffic safety. Task force on road safety of the working party on accident and injuries, Vienna 2005, page 8.

[5] (05) cp. Kisser, R., Kormer, C., Sengolge. M.. Actions for the public health sector to improve road traffic safety. Task force on road safety of the working party on accident and injuries, Vienna 2005, page 8.

This question concern all types of road users, but it becomes even more critical as far as pedestrians are concerned, given that in this case no other reliable approximation of the amount of risk exposure is available than the population. For instance, vehicle- and passenger-kilometres of travel or vehicle fleet are partly available at international level and may be used as measures of exposure for vehicle occupants. However, no such data is available for pedestrians. Certainly, several countries perform travel / mobility surveys, in which the number of pedestrian trips performed and the time spent in traffic as pedestrian can be calculated at national level. However, these results are not available in international databases, and important effort would be required in order to achieve comparability of this data, because the features of the surveys (frequency, representativeness, sample size, survey design etc.) may vary significantly across countries (Yannis et al. 2008). It is equally important to better align these surveys to road safety analysis needs, given that they mostly have other purposes than to provide exposure data for safety analyses.

Figure 1 Under-reporting of pedestrian injuries in Europe



Source: Broughton et al. 2007 Note: Under reporting coefficients are calculated as the ratio of the number of actual casualties of a given severity to the number of casualties recorded by the Police.

Summarizing, an important amount of reliable information on pedestrian safety is available in international databases, as a result of considerable efforts made in the last decades. Particularly the CARE database of the European Commission and the IRTAD database of the OECD/ITF include pedestrian accident and casualty data for several countries and years, which can be analyzed in relation to a number of harmonized variables.

However, several issues need to be addressed as regards pedestrian safety data, namely the standardization of definitions (pedestrian, pedestrian road accident, pedestrian injury, serious or slight etc.), the estimation of pedestrian injury under-reporting through the exploitation of medical data and the collection and harmonization of pedestrian risk exposure data (mobility etc.). These issues concern the safety data of all road users, but are even more critical for pedestrians and thus need to be kept in mind when analyzing international pedestrian safety data.

Despite these limitations, the following sections will describe, based on the best available information the situation regarding:

- Non traffic accidents
- Traffic accidents involving pedestrians.

3. Non traffic accidents - Pedestrian Falls

Falls are a leading cause of injury for people of all ages, and especially for the elderly. While a large percentage of falls occur on stairs and inside buildings or homes, pedestrians walking or jogging on sidewalks, stepping off curbs, and crossing roadways also fall, and this information is largely unreported. There is therefore little data available on the magnitude and consequences of pedestrian falls. Falls are yet a prevalent public health problem with significant human and economic consequences.

3.1. Pedestrian falls: magnitude of the problem

A recent study estimated that every year in Europe 1.6 million pedestrians get injured due to falls on public roads in the European Union (Kormer and Smolka, 2009)[6], and an unknown number of people die for the same reason. (see table 1). This represents almost 3,000 victims per million inhabitants.

The Netherlands undertook in 2009 an in-depth study[7] of pedestrian and bicycle accident, which assessed the real number and severity of these accidents. This study revealed that most victims among pedestrians and bicyclists come from single accident.

The study showed that:

- around 1/3 of pedestrian fatalities were due to falling,
- 80% of pedestrian injuries are due to falling.

Figure 2 Estimated number of injuries due to falls (from Kormer and Smolka, 2009).

Country	Non-fatal home and leisure injuries without sport****	Injuries due to FiP	Percentage of injuries due to FiP in home and leisure injuries
AT	465.750	41.796	9%
DK*[80]	385.560	35.315	9%
FR[81]	3.847.500	96.716	3%
NL**	523.260	32.500	6%
SE***	422.820	24.120	6%
Subtotal	**1.411.830**	**98.416**	**7%**
Min			**3%**
Max			**9%**
EU25******	**22.680.000**	**1.580.980**	
EU25 rounded		**1.580.000**	

* Source: Danish Injury Register 2004

**Source: Dutch Injury Surveillance System 2004, Consumer Safety Institute

***Source: IDB 2004, Epidemiological Centre, The National Board of Health and Welfare, SE

**** Source: IDB Report 2002-2004, excluding sports injuries (19% of the total estimated injuries)

The most important types of accidents according to volume are: single bicycle accidents, single pedestrian accidents, pedestrian crossing accidents, bicycle crossing accidents, pedestrian and bicycle accidents near public transport stops and trains crossings. Little is known about the circumstances, causes and possible measures to be taken.

[6] Kormer and Smolka (2009). *Injuries to vulnerable road users including Falls in Pedestrians in the EU; A data report. APPOLO project* KFV, Vienna
http://www.euroipn.org/apollo/reports/D5.2_Apollo_VRU_InjuryDataReport_090210.pdf

[7] Methorst R, van Essen M, Ormel W and P. Schepers (2010) *Pedestrian and bicyclist injury accidents in the Netherlands : a surprising image.* Rijkswaterstaat Centre for Transport and Navigation, Delft.

Swedish studies (Oberg, 1996, Larsson, 2009)[8] showed similar results with 75% of injured pedestrians due to Pedestrian only events.

Average number of victims per year (2003 – 2007) – real numbers				
	Deceased	Hospitalised (excl. deceased)	Urgent Medical Assistence (excl. Hospitalised)	Total
Pedestrians	**150**	**5.200**	**49.700**	**55.000**
Of which single accidents	*45*	*4.000*	*45.900*	*50.000*
Of which traffic accidents	*105*	*1.200*	*3.800*	*5.000*
Bicyclists	**220**	**7.600**	**60.200**	**68.000**
Of which single accidents	*50*	*6.000*	*47.500*	*53.500*
Of which multiple vehicle	*170*	*1.600*	*12.700*	*14.500*
Other modes	**595**	**8.200**	**48.100**	**57.000**
Total	**965**	**21.000**	**158.000**	**180.000**
NB. The numbers are rounded and corrected for doubles				

Table 1 Real number of pedestrian injuries in The Netherlands, 2003-2007

		Traffic accident	Non traffic accident	Total
Sweden (1998-2007)	**Injured pedestrian (number)**	6433	19656	26089
	Injured pedestrians (%)	25%	75%	100%

Table 2 Pedestrian injuries in Sweden. (Larsson, 2009)

The 1999 US study on "Injuries to pedestrians and bicyclists"[9] analysed the circumstances of 1345 cases of pedestrian injuries. It showed that 64% of pedestrian injuries did not involve a motor vehicle.

The Spanish National Health Survey[10] for 2006 recorded all citizens injury by location. In Spain, there are as much people injured in a traffic accident than falling in the street. Falling accounts for 16% of all injuries, whereas 31% people injured following a home injury.

3.2. Location of pedestrian non traffic accident

Table 3 and 4 illustrate the location of pedestrians' falls in the EU and US studies.

Location	%
Pavement, pedestrian mall	30
Public road inside urban area	29
Cycle way	14
Road, unspecified	9
Public road outside urban area	9
Transport area, other specified	4
Bus station, railway area, freight terminal, etc.	4
Transport area, unspecified	1
Total	100

Table 3 Location of pedestrian's non traffic accidents

[8] Oberg (2006), *Injured pedestrian in Sweden: surface condition.* VTI, Sweden. Larsson (2009), *Traffic Safety problems for pedestrians – Injuries according to police reports and health service,* VTI report (in Swedish)
[9] US Department of Transportation (1999), *Injuries to pedestrians and bicyclists : an analysis based on hospital emergency department data*
[10] Ministeria de Sanidad y Politica Social (2006). *Encuesta Nacional de Salud de Espana, 2006,* http://www.msc.es/estadEstudios/estadisticas/solicitud.htm

Location of Injury Event	Type of Injury Event		Total
	Pedestrian – motor vehicle	Pedestrians Only	
Roadway	439 (70.0)[1] (88.0)[2]	188 (30.0) (22.2)	**627** **(46.6)**[2]
Non-Roadway[11]	60 (8.4) (12.0)	658 (91.6) (77.8)	**718** **(53.4)**
Unknown	23 (23.5) (--)	75 (76.5) (--)	**98** **(--)**
Total	**522** **(36.2)**[1]	**921** **(63.8)**	**1443**

Table 4 Distribution of pedestrian injury cases treated in hospital
[1] Percentage of row total.
[2] Percentage of column total (excluding unknown cases).

3.3. Who are the victims?

The European study showed that the ratio of males and females injured following a fall is almost equal (52:48). Similar result was found in the US study.

The European study showed that children (0-14) followed by the elderly (65+) are especially affected by such injuries. More than three quarters of all pedestrian injuries happen during general walking around. 9% of pedestrian injuries happen during other activities, 6% during play and leisure activities, 4% during sports or athletics activities. 2% of pedestrian injuries happen during shopping, 1% during a vital activity such as eating or drinking. (see Table 5)

Activity	%
General walking around	78
Other activity	9
Play and leisure activity	6
Sports or athletics activity	4
Shopping	2
Vital activity	1
Total	100

Table 5 Falls in Pedestrians by activity

Table 6 provides information on the **ages** of pedestrians treated at the participating hospital emergency departments in the US 1999 study. Children under 5 years of age were especially overrepresented in non-roadway motor vehicle collisions. Older adults, in contrast, were overrepresented in pedestrian-only events occurring in non-roadway locations: 38 percent of these events involved adults in the 45-64 or 65+ age groups.

For the 45- to 64-year-olds, more than 40 percent of their non-roadway falls occurred in icy weather conditions. With these cases subtracted from the table, the 45-64 age group would no longer be overrepresented in non-roadway pedestrian-only events. The oldest pedestrians, age 65+, would remain overrepresented in non-roadway pedestrian-only events even with the icy weather incidents removed.

[11] Non roadway location can include : parking lots, train station, …

Pedestrian Age	Ped Only Road	Ped Only Non-Road
0-4	4 (2.2)	38 (5.8)
5-9	12 (6.5)	57 (8.7)
10-14	34 (18.5)	69 (10.6)
15-24	48 (26.1)	76 (11.7)
25-44	46 (25.0)	167 (25.6)
45-64	22 (12.0)	142 (21.8)
65+	18 (9.8)	103 (15.8)
Total	184	652

Table 6 Age distribution of pedestrians by type of injury event.
[1] Percentage of column total.

Skates and skateboard

In most countries, skaters and skateboards are considered as pedestrians (whether they circulate on the roadway or on the sidewalk).

In the US study, of the nearly 200 pedestrian-only events that occurred ***in the roadway***, one-fourth involved the use of in-line skates and an additional 5 percent involved persons on skateboards. ***Off-road***, the situation was not much safer: 12 percent of the injured pedestrians were using in-line skates and 3 percent were using skateboards. These percentages are combined for all ages and would be higher for teens or young adults. While education efforts might help to alert young people to the dangers of these activities, a better alternative might be to provide a safer environment for skating, such as a network of well-maintained off-road trails.

Skaters and state boarders can also be a danger for the *real* pedestrians walking on the sidewalk.

3.4. Type of injuries

The European study showed that about three quarters (74%) of all pedestrians hurt their extremities (lower extremities 42%, upper extremities 32%) in injuries, followed by head injuries at 20%. All other body parts make up the remaining 5%. Fractures happen to about 30% of all injured pedestrians; contusions account for around 20% and distortions for more than 15%. Open wounds contribute to 15% of the total and lesions of tendon(s) and/or muscle(s) for 7%. The US study show similar types of injuries.

3.5. Accident causation factors

Although pavement and sidewalk conditions can be assumed to be an important factor in falls, very few hard data were found to substantiate this. In countries with marked winter conditions, snow and ice are reported as particularly hazardous for pedestrians. In Sweden the primary cause is slipping due to ice and snow (more than 50% of accidents). In wintertime in there are 3 – 4 times more injuries than in high summer months. In Buffalo, New York, which experienced considerable snow and ice during the winter of 1995-96, over a fourth of all pedestrian injuries reported by the hospitals *during the entire year of data collection* were icy weather related.

Pedestrian-Only Roadway	Pedestrian-Only Non-Roadway
% Injury Type All	**% Injury Type All**
Lower limb (38%) 37% sprain/strain 29% fractures 14% contusions 13% superficial	**Lower limb (35%)** 33% sprain/strain 31% fractures 21% contusions 8% superficial
Upper limb (32%) 39% fractures 18% sprain/strain 16% contusions	**Upper limb (30%)** 47% fractures 21% contusions 17% sprain/strain
Face / neck (16%) 60% lacerations 18% contusions	**Head (13%)** 50% contusions 23% lacerations 12% other 10% superficial
Head (7%) 47% lacerations 35% contusions	**Face / neck (13%)** 41% lacerations 22% contusions 15% superficial

Table 7 Most frequent injuries for pedestrian only accident
[1] Percent of all injuries occurring to pedestrians in that injury-type group.

Unevenness, potholes and rutting make up for 12% of the cases. Lack of maintenance, such as slipperiness of leaves and loose gravel, cause about 4% of the injury accidents; for a large proportion (some 25%) of accidents the cause is unknown[12].

In warmer countries the distribution of causes can be expected to show that about half of the falling accidents are at least partly caused by unevenness, potholes and rutting, and some 10% by maintenance problems.

In addition to clearing roadways and making them safe for motor vehicle travel, sidewalks, driveways, and parking lots need to be made as safe as possible for pedestrian travel. Too often, roadways are cleared at the expense of sidewalks, and little, if anything, is done to help pedestrians negotiate parking lots once they arrive at their destinations.

Alcohol is an important contributing factor in both traffic and non traffic pedestrian accident. it however seems that persons injured in pedestrian-only events were generally less likely to have been drinking than those struck by motor vehicles. In the US study, just under 6 percent of the pedestrians injured in pedestrian-only events were "indicated as impaired," while only a little over 1 percent were tested and found to have a positive blood-alcohol level. The majority (60%) of the accidents occurred on the sidewalk.

3.6. Cost of pedestrians falls

Very little data exist. The information below is based on the Dutch study (Methorst et al, 2009) which shows that almost 60% of all societal costs of travel accidents (including falls) are related to bicycle and pedestrian accidents.

As 30% of killed pedestrians and 80% of pedestrians injuries are to due to falling, this means that around pedestrian falls costs to the Dutch society around 1.4 billion Euros every year (i.e. 16% of total traffic accidents).

[12] Source: presentation by G. Öberg at the Vulnerable Road Users Conference, June 2010.

The costs are so high because particularly the number of treatments in Emergency Rescue departments of hospitals and number of hospital admittances are extremely high. Government is confronted with high medical costs, costs of employment disabilities, transport costs within the context of the Social Support Act etc.

	Total		Killed persons	Hospital admitances	Urgent Medical assistence
	Total	Per inhabitant			
Pedestrians	2.065	130	370	1.300	400
Bicyclist	2.920	180	540	1.900	480
Other Modes	3.895	240	1.460	2.050	385
Total	8.880	540	2.370	5.250	1.265

Table 8 Summed travel accident costs in the Netherlands (x million Euros, rounded)

4. Road traffic accidents involving pedestrians

Despite the fact that pedestrian road traffic casualties in the OECD countries presented a constantly decreasing trend during the last years, the number of pedestrians involved in road accidents in several countries and as a whole is still unacceptable and illustrates the need for even greater efforts with respect to pedestrian safety. Most importantly, it is observed that the peak or abnormal situations remain practically unchanged over this period, suggesting a persistence of the basic pedestrian risk factors (OECD, 2001; ERSO, 2008a). In particular, in 2006 there were more than 78,000 fatalities in road traffic accidents in 23 OECD countries[13], out of which more than 11,000 were pedestrian fatalities, and out of which more than 7,500 occurred in urban areas.

The objective of this section is the analysis of existing data issues on pedestrians' safety in urban areas, at national and international level. In particular, the analysis aims to identify the main questions of pedestrian safety data needs, availability and quality and to present pedestrian safety data for the creation an overall picture on the current potential for pedestrians' road safety analysis in urban areas in OECD countries.

These issues are discussed in terms of data needs and potential for analyses for policy making. Two main categories of data are discussed namely macroscopic data, as those typically available in international databases, and detailed / in-depth data often available at national level. The distinction implies not only different scales and objectives of analysis but also significantly different data availability and quality issues. On the one hand, macroscopic data are useful and comparable data sources that may provide an overall picture of basic trends and figures related to pedestrian safety. On the other hand, the need for detailed analysis allowing the identification of specific factors and patterns of pedestrian accidents can only be addressed through the exploitation of much more detailed information available at national level.

These questions and methods related to pedestrian safety data are analyzed in the following sub-sections. Existing pedestrian safety data are presented and interpreted in terms of key factors of pedestrian safety. In particular, data from the CARE database of the European Commission and the IRTAD database of the OECD/ITF are initially used, together with related data from other OECD countries, collected by means of a questionnaire, and information from national fact sheets on pedestrians.

[13] AT, AU (2008), BE,CA, CZ, DK, EE, ES, FI, FR, GR, HU, IL, IT, JP (2008), LU, LV, MT, NL, PT, SE, UK, USA (2008),.

The potential, advantages and limitations for exploiting existing data for decision making are discussed. Finally, particular emphasis is put on data quality issues during the analysis, so as to limit the consequences of incompatible data definitions and collection methods.

4.1. Macroscopic pedestrian safety data analysis in the OECD/ ITF countries

Macroscopic safety data issues

Road safety data, including pedestrian safety data, are gathered, processed and stored in international data files, such as the IRTAD database of the OECD/ITF, the CARE road accident database of the European Commission, the Eurostat databases, the data of the International Transport Forum, etc. The data included in these databases are based on national road accident statistics, which are mostly based on information collected by the Police. In Europe, only the CARE database includes disaggregate information, whereas the other databases include aggregate data.

These data files are useful and accessible data sources, as a result of several decades of important data collection efforts. However, they may have different objectives; they may collect different data in different forms and structure, and they are maintained by organizations with different scopes and policies (Yannis et al., 2005). Moreover, the availability and quality of the data may vary as well, mainly due to different national definitions of variables and values.

In some databases (e.g. IRTAD, CARE), appropriate data transformation rules have been developed in order to obtain comparable information for a number of basic variables and values. The CARE database currently includes 17 harmonized variables, concerning person, vehicle, road and accident characteristics (European Commission, 2006).

The adoption of a common international definition of road accident fatality, as a fatality that occurred within 30 days from the accident, has significantly contributed to the international comparability of fatality data. However, such common definitions have not yet been proposed for injury data, although significant efforts are made. It is therefore strongly recommended that international comparisons are limited to fatality data.

Especially as regards pedestrian safety data, additional questions may rise from the lack of common international definition of pedestrians. In the CARE database, a common definition for pedestrians is available, it is though indicated that this definition is not fully applicable in all countries. More specifically, the Glossary of the CARE database (European Commission, 2006) mentions the following definition, where it is obvious that different definitions of pedestrian are used in different European countries:

"Definition: Person on foot. Person pushing or holding bicycle (except DK). Person pushing a pram or pushchair. Person leading or herding an animal (except AT, DK). Person riding a toy cycle on the footway (except AT). Person on roller skates, skateboard or skis (except AT). Does not include person in the act of boarding or alighting from a vehicle (except DK, ES)".

Furthermore, the definition of a pedestrian road accident is not harmonized at international level. Most databases include pedestrian road accidents in which pedestrians were injured during an interaction with a motorized or non-motorized vehicle. Consequently, injuries resulting from falls (e.g. on the road surface, on metro stairways, inside public transport etc.) are not recorded by the Police and generally not included in the national or international databases (link to section on non-motorized accidents).

4.2. Overview of pedestrian safety for OECD / ITF countries

This sub-section presents the basic road safety facts for pedestrians in OECD countries. The road safety data were extracted from the IRTAD database and the CARE database for year 2006 or for the last available year. The respective population data were extracted from the OECD and the Eurostat databases for the period 1991-2006 and the variables considered are person age and gender. The analysis is completed with information from national fact sheets on pedestrians, when available.

General trends and basic figures

In 2008, pedestrians represented between 8 and 36% of traffic fatalities in the OECD countries. The lowest percentages were found in The Netherlands (8.3%) and New Zealand (8.5%) and the highest percentages in Israel, Japan, Poland and Korea, with more than 30% pedestrians among the road fatalities.

These data must be interpreted with care, and sufficient knowledge of exposure data (e.g. number of walking trips, number of elderly with a driving license) are necessary to understand the pedestrian safety condition of each country. As an example, Japan has a very high percentage of pedestrian fatalities (32.8%), that can be partly explained by the fact that very few people older than 65 have a driving license. Usually, higher percentages of fatalities are found in less developed countries where pedestrians frequently represent more than half of the causalities.

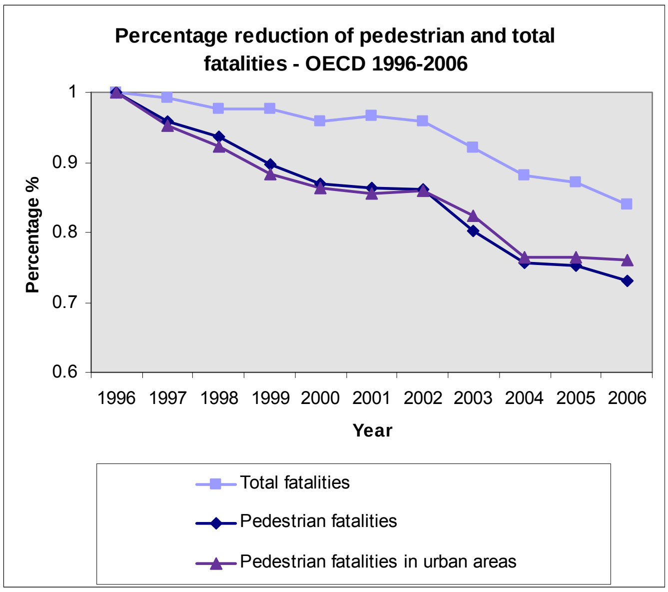
	Pedestrian fatalities	Total fatalities	% of pedestrians
Australia	190	1442	13.2%
Austria	102	679	15.0%
Belgium	99	944	10.5%
Czech Republic	238	1076	22.1%
Denmark	58	406	14.3%
Finland	53	344	15.4%
France	548	4275	12.8%
Germany	653	4477	14.6%
Hungary	251	996	25.2%
Iceland	0	12	n.a
Ireland	49	279	17.6%
Israel	134	412	32.5%
Italy	648	4731	13.7%
Japan	1976	6023	32.8%
Korea	2137	5870	36.4%
Luxemburg	4	35	11.4%
Netherlands	56	677	8.3%
New Zealand	31	366	8.5%
Norway	33	255	12.9%
Poland	1882	5437	34.6%
Slovenia	39	214	18.2%
Spain	502	3100	16.2%
Sweden	45	397	11.3%
Switzerland	59	357	16.5%
United Kingdom	591	2645	22.3%
United States	4378	37261	11.7%
Total	**14756**	**82710**	**17.8%**

Table 9 Number and share of pedestrians killed (2008)
Source: OECD/ITF, 2010.

Figure 3 shows that pedestrian fatalities in the OECD countries present a more significant decrease than total fatalities during the last decade. However, during the last five years, the reduction of pedestrian fatalities inside urban areas is somewhat lower than the reduction of total pedestrian fatalities. It is noted that the peak shown in 2002 is due to an important increase of pedestrian fatalities in Italy on that specific year.

For countries for which IRTAD data are available the number of pedestrian killed decreased between 32% (in the United States) and 70% (New Zealand and Korea). In all countries except Japan the number of pedestrian fatalities decreased more rapidly than the number of overall road fatalities (see Table 10).

Figure 2 Percentage reduction of pedestrian fatalities and total fatalities in the OECD countries, 1996-2006.



Source: CARE database (date of query: September 2009), OECD questionnaire Countries: AT,AU,BE,CA,DK,ES,FI,FR,GR,IE (up to 2003),IL,IT,JP,NL,PT,SE,UK,USA.

Pedestrian fatality rates

The average pedestrian fatality risk in urban areas in terms of *pedestrians killed per million inhabitants* (Figure 2) in the examined OECD countries is equal to 13.7 pedestrians per million inhabitants. It is noted that population figures concern the total country population. The fatality rates range from 2 to 10 in northern and western European countries, USA, Canada and Australia, from 10 to 15 in southern European countries and Japan, and from around 12 to 30 in the EU New Member States. This unbalance within the EU countries as regards pedestrian safety may be explained as follows: as regards southern European countries, it may be attributed to increased exposure of pedestrians, as a result of favourable climate, whereas as regards the new Member States, it is more likely associated with increased exposure of pedestrians due to low motorization levels (ETSC, 2006). The related pedestrian fatality risk in Mexico is by far the highest and reaches 40 pedestrian fatalities in urban areas per population.

Overall countries with low rates are the same than countries with general good road safety level.

	Evolution in pedestrian fatalities 1990-2008	Evolution in total fatalities 1990-2008
Australia	-55%	-38%
Austria	-61%	-56%
Belgium	-67%	-52%
Czech Republic	-34%	-17%
Denmark	-51%	-36%
Finland	-50%	-47%
France	-64%	-62%
Germany	-69%	-59%
Hungary	-69%	-59%
Ireland	-67%	-42%
Israel	-39%	-34%
Italy	-50%	-59%
Japan	-60%	-51%
Luxemburg	-61%	-51%
Netherlands	-70%	-50%
New Zealand	-40%	-23%
Norway	-37%	-26%
Poland	-70%	-59%
Slovenia	-67%	-66%
South Korea	-66%	-49%
Spain	-65%	-61%
Sweden	-66%	-51%
Switzerland	-32%	-16%
United Kingdom	-54%	-41%
United States	-55%	-38%
Total	-61%	-56%

Source: OECD/ITF, 2010

Table 10 Relative evolution in the number of pedestrian deaths and total deaths (1990-2008)

The average *number of kilometres walked per pedestrian death* is a valid indicator as it allows taking into account the exposure of pedestrians. For example, in the United States, 1 pedestrian crash fatality occurs for every 113 km walked. Unfortunately, such information is not available in most countries.

Accident locations

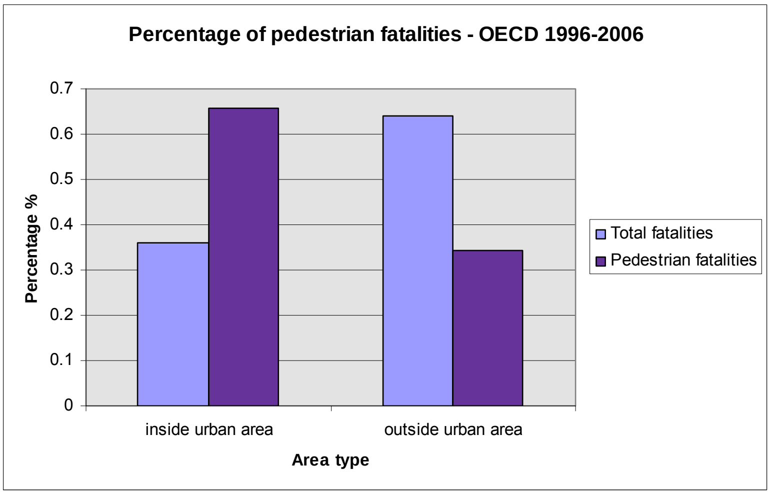
Although most of all fatalities occur outside urban areas, the majority (around 70-80%) of reported pedestrian crashes happened in urban areas. This is due to the fact that most of the population live in urban areas and also that those who live in urban areas, walk more than people living in rural areas.

	Pedestrian fatalities	Population (in million)	Pedestrian deaths / million inhabitants	Fatalities / 100 000 population
Iceland	0	0.315	na	3.8
Netherlands	56	16.404	3.41	4.1
Sweden	45	9.183	4.90	4.3
Norway	33	4.737	6.97	5.4
New Zealand	31	4.269	7.26	8.6
Switzerland	59	7.593	7.77	4.7
Germany	653	82.218	7.94	5.4
Luxemburg	4	0.484	8.26	7.2
France	548	61.876	8.86	6.9
Australia	190	21.374	8.89	6.7
Belgium	99	10.667	9.28	8.8
United Kingdom	591	61.383	9.63	4.3
Finland	53	5.300	10.00	6.5
Denmark	58	5.512	10.52	7.4
Italy	648	59.619	10.87	7.9
Spain	502	45.283	11.09	6.8
Ireland	49	4.401	11.13	6.3
Austria	102	8.332	12.24	8.1
United States	4378	304.060	14.40	12.3
Japan	1976	127.692	15.47	4.7
Israel	134	7.490	17.89	5.5
Slovenia	39	2.057	18.96	10.4
Czech Republic	238	10.381	22.93	10.4
Hungary	251	10.045	24.99	9.9
South Korea	2137	49.232	43.41	11.9
Poland	1882	38.116	49.38	14.3

Source: OECD/ITF, 2010

Table 11 Pedestrian Fatality rates in OECD countries (2006)

Figure 3 Percentage of pedestrian fatalities and total fatalities per area type in the OECD countries, 1996-2006.



Source: CARE database (date of query: September 2009), OECD questionnaire;
Countries: A, AU, BE, CA, DK, ES, FI, FR, GR, IE (up to 2003), IL, IT, JP, NL, PT, SE, UK, USA.

Accidents at intersections
In urban areas, around two third of crashes happened outside (or near) crossing and one-third at pedestrian crossing.

In Great Britain, more than half of reported pedestrian casualties were crossing the road when injured. Of these, 19% were on a pedestrian crossing and a further 12% in the very near (less than 50 metres) proximity of a pedestrian crossing. Of the remaining 43% of casualties: 14% were masked by a stationary vehicle; 10% were in the carriageway but not crossing and 10% were on the pavement or verge.

In Canada, more than 60% of pedestrians who were killed in traffic crashes were trying to cross a road (with or without the right of way) at the time of the incident. Among senior pedestrians only, the figure was 78%. Crossing at an intersection with no traffic control, specifically, seemed to be the most hazardous action for pedestrians. This behaviour accounted for more than 25% of pedestrian fatalities (and 33% of senior pedestrian fatalities). Close to 10% of fatally injured pedestrians were crossing an intersection with the right of way when a vehicle struck them. Another 7% were crossing at a crosswalk.

In the United States, over three-fourths (78%) of the pedestrians were killed at non-intersections and less than one-fourth (21.2%) were killed at intersections over the past decade. Table 11 shows that roadways without crosswalks accounted for 42% of all pedestrian fatalities. The Table also shows that the percentage of pedestrian deaths in crosswalks (near 9%) is less than deaths in roadways (80%). This indicates that using a crosswalk is the safest way to cross a street.

Pedestrian Location	Section			Total
Crosswalk Availability	Roadway	Crosswalk	Other	
Available	21.1%	8.8%	0.0%	29.9%
Not Available	41.8%	0.0%	6.1%	47.9%
Unknown	16.8%	0.0%	5.4%	22.2%
Total	79.7%	8.8%	11.5%	100.0%

Source: FARS 1997-2005 (Final), 2006 (ARF)

Table 10 Distribution of pedestrian fatalities by roadway section and crosswalk availability, United States, 1997-2005

In France, in 2006, most of the pedestrian crashes in urban areas occurred during the day and 37% of fatal crashes occurred at a pedestrian crossing (see Table 12). This share has been increasing recently.

Pedestrian fatalities in relation to the proximity of a pedestrian crossing	Day	Night	Total
At a pedestrian crossing	94	45	**139**
Less than 50 m of a pedestrian crossing	86	34	**120**
More than 50 m of a pedestrian crossing	24	22	**46**
Others	49	19	**68**
Total	**253**	**120**	**373**

Source: ONISR, 2008

Table 11 Location of pedestrian fatalities in relation and distance to a pedestrian crossing, France, 2006

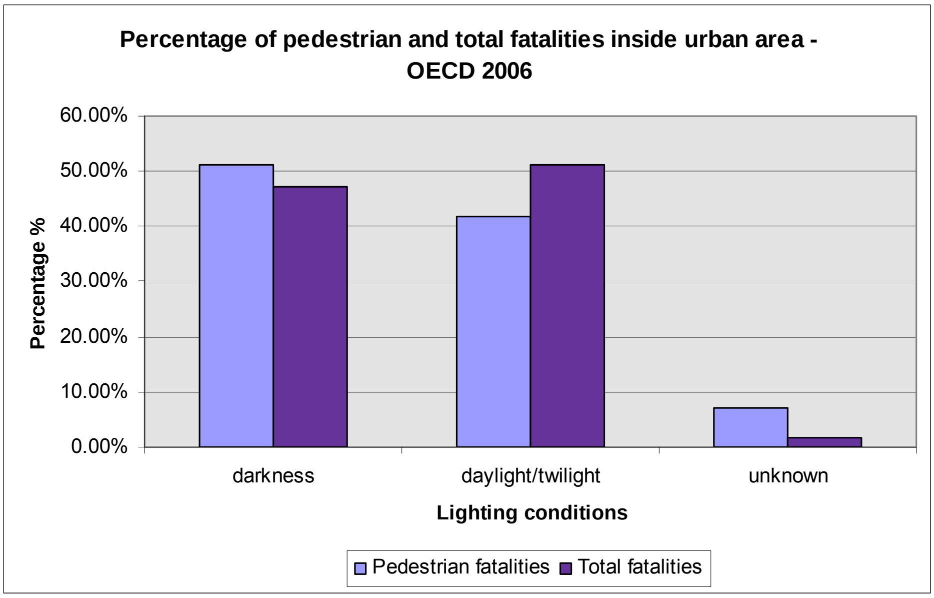
Finally, in Greece on year 2008, 25% of pedestrian fatalities inside urban areas occurred while not complying with the spatial or temporal traffic rules at crosswalks (i.e. crossing during red signal or outside the marked crosswalk area). Moreover, 41% of pedestrian fatalities inside urban areas occurred while crossing at uncontrolled locations, while another 11% occurred while walking on the road pavement, instead of using the sidewalk.

Road lighting and time of day

As regards the effect of road lighting (Figure 5), although the majority of all fatalities inside urban area occur at daylight, the majority of pedestrian fatalities inside urban area occur at darkness, despite the reduced exposure of pedestrians during the night. The non-negligible percentage of unknown values for lighting conditions does not allow for conclusions to be drawn in this case, however, darkness appears to be a risk factor associated with pedestrian fatalities inside urban areas.

In the United States and Canada, the peak time for fatal pedestrian traffic crashes in general was 6 p.m. to 9 p.m.

Figure 4 Percentage of pedestrian and total fatalities inside urban area per lighting conditions, OECD - 2006



Source: CARE database (date of query: September 2009), OECD questionnaire; Countries: AT,BE,CA,CZ,DK,EE,ES,FI,FR,GR,HU, IE (2003),IL (2008), IT,LU (2005),LV,MT,NL,PT,PL (2005),SE,JP,AU (2008),USA (2008), UK.

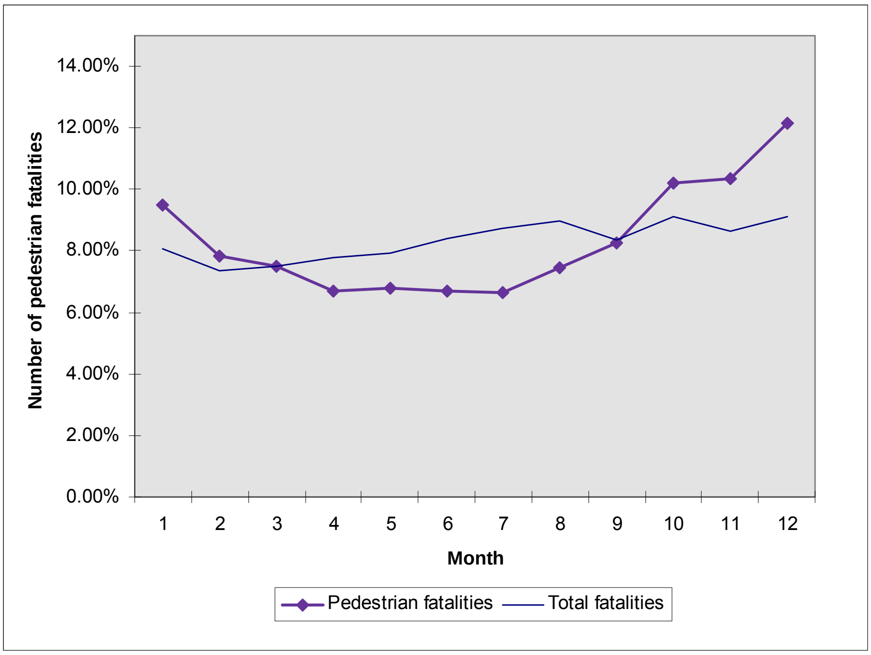
Seasonality

Another interesting pattern rises from the examination of the monthly variation of pedestrian fatalities in the OECD countries, shown in Figure 6. More specifically, while the total number of road accident fatalities inside urban areas peaks during the spring / summer period (April to August), the number of pedestrian fatalities inside urban areas peaks during the fall / winter period (October to January), despite the fact that pedestrians exposure is expected to decrease during that period. It is likely that poor lighting conditions and adverse weather conditions result in increased occurrence of pedestrian accidents inside urban areas during the winter.

Gender

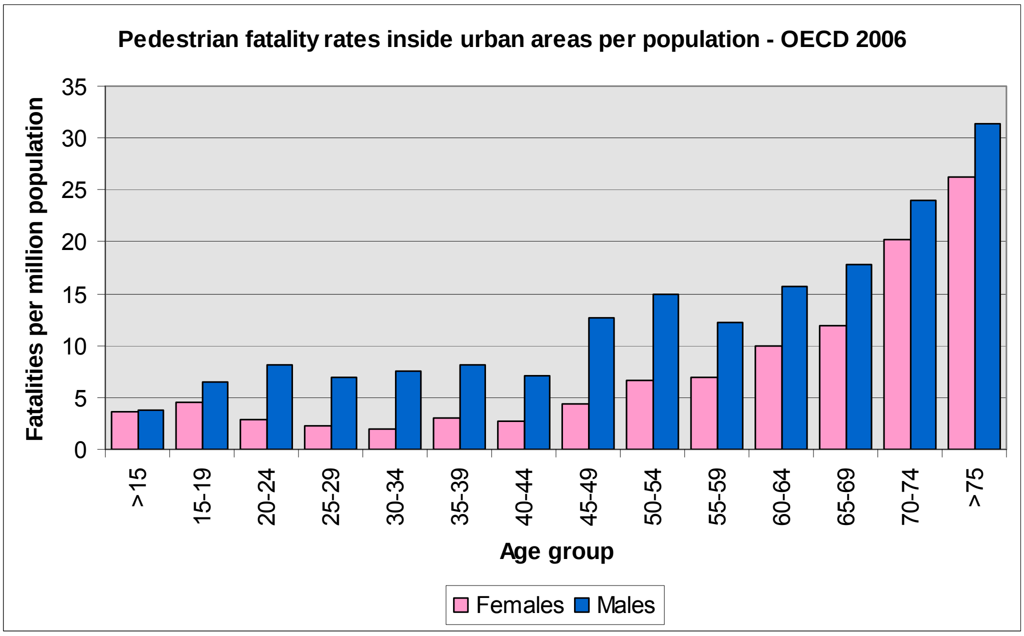
The effect of pedestrian age and gender on fatality rates of pedestrians inside urban areas present an interesting pattern (Figure 7). In general, male pedestrians have higher fatality rates than females. It is likely that this is a result of differences in behaviours of males compared to females (Yagil 2000). However, fatality rates become more balanced between males and females for elderly pedestrians (>65 years old), and are significantly increased compared to the other age groups.

Figure 5 Percentage of pedestrian and total fatalities inside urban area per month, OECD - 2006



Source: CARE database (date of query: September 2009), OECD questionnaire; Countries: AT,BE,CA,CZ,DK,EE,ES,FI,FR,GR,HU,IE (2003),IL (2008),IT,LU (2005),LV,MT,NL,PT,PL (2005),SE,JP,AU (2008),USA (2008), UK.

Figure 6 Pedestrian fatality rates (fatalities per million population) inside urban area per age and gender, OECD - 2006



Source: CARE database / Eurostat (date of queries: September 2009), OECD questionnaire; Countries: AT,BE,CZ,DK,EE,ES,FI,FR,GR,HU,IE (2003),IT,LV,NL,PT,PL (2005),SE,UK.

Age

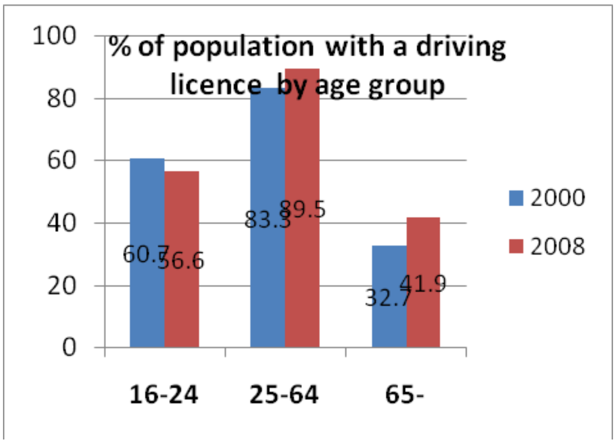
In all countries, senior pedestrians (+65) are the most at risk and play a very heavy tribute. As the population ages, the number of fatalities from this demographic can be expected to increase unless steps are taken to improve pedestrian safety. The percentage of 65+ among pedestrian fatalities is much higher than the percentage of 65+ in the overall population (see Table 13). The situation varies from country to country. In Japan, for example, elderly people represent 22% of the population but 68% of pedestrian fatalities. In Switzerland, elderly people represent 16% of the population and 61% of pedestrian fatalities. The US is the country with the less difference.

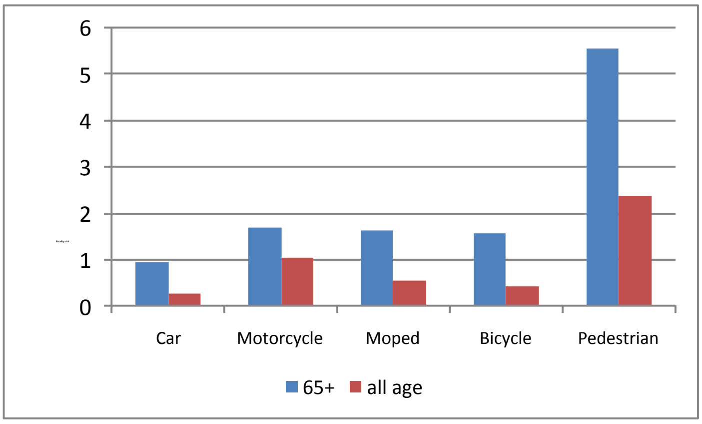
	65+	
	% in population	% in pedestrian fatalities
Australia	13%	33%
Austria	17%	57%
Czech Republic	15%	35%
Denmark	16%	40%
Finland	17%	53%
France	17%	48%
Germany	20%	50%
Japan	22%	68%
Netherlands	15%	39%
New Zealand	13%	23%
Norway	15%	36%
Spain	17%	43%
Sweden	18%	42%
Switzerland	16%	61%
United Kingdom	16%	37%
United States	13%	18%

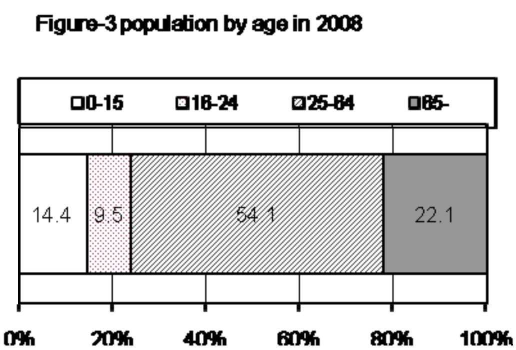
Source: OECD/ITF, 2010

Table 12 Percentage of elderly in population and in pedestrian fatalities

Figure 7 Some elements to explain the high rate of pedestrian fatalities in Japan



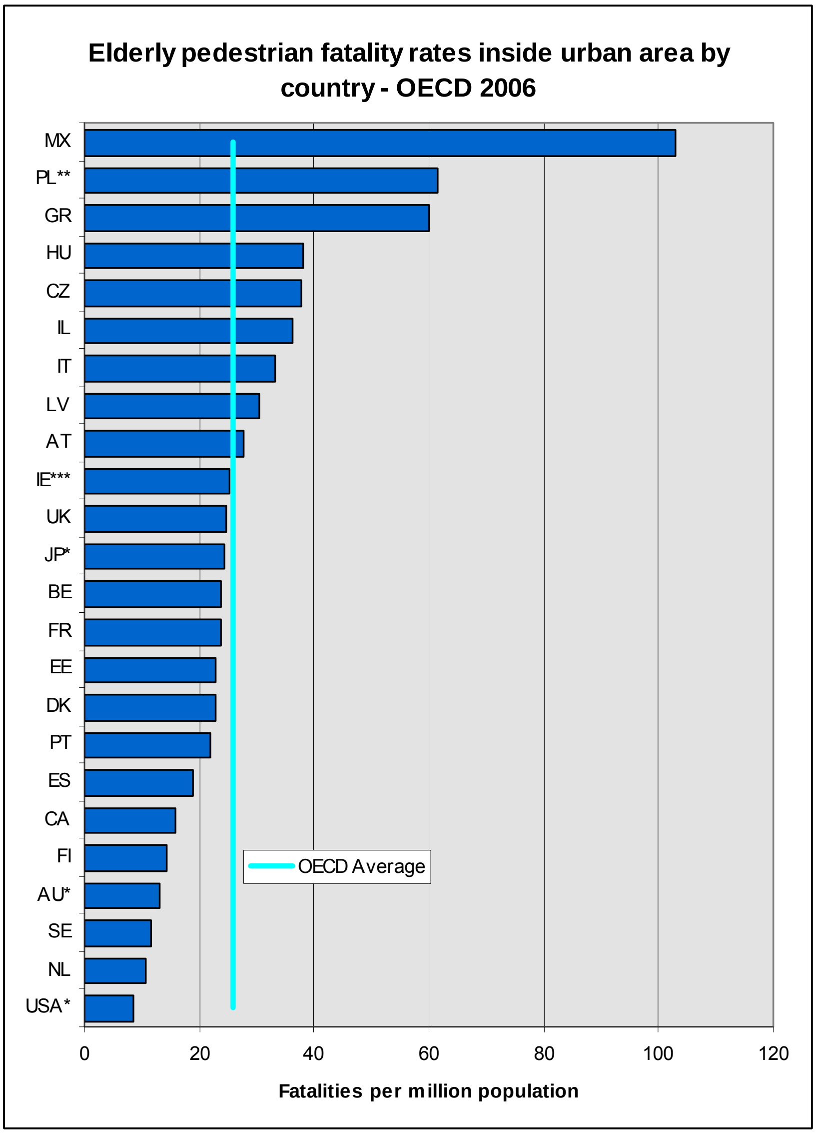




A reason for the increased risk of elderly pedestrians could be the even more increased physical vulnerability, together with a lower level of motorization in this age group, the latter reflecting an exposure pattern (OECD, 2004).

The over-representation of older citizens in road fatalities can be explained by their higher exposure (they drive less) and their greater fragility. Older pedestrians may have reduced sight, hearing or motor skills, or mental functioning. This can affect their ability to get around safely. Older pedestrians may be slower to perceive and react to traffic. They often need more time to cross the street than other pedestrians. In fact, right-of-way conflicts are a significant risk factor. In Canada, about 16% of fatally injured senior pedestrians were struck by a driver who failed to yield the right of way. Busy urban streets are especially dangerous for this age group.

Figure 8 Elderly pedestrian fatality rates (fatalities per million population) inside urban area per country, OECD - 2006



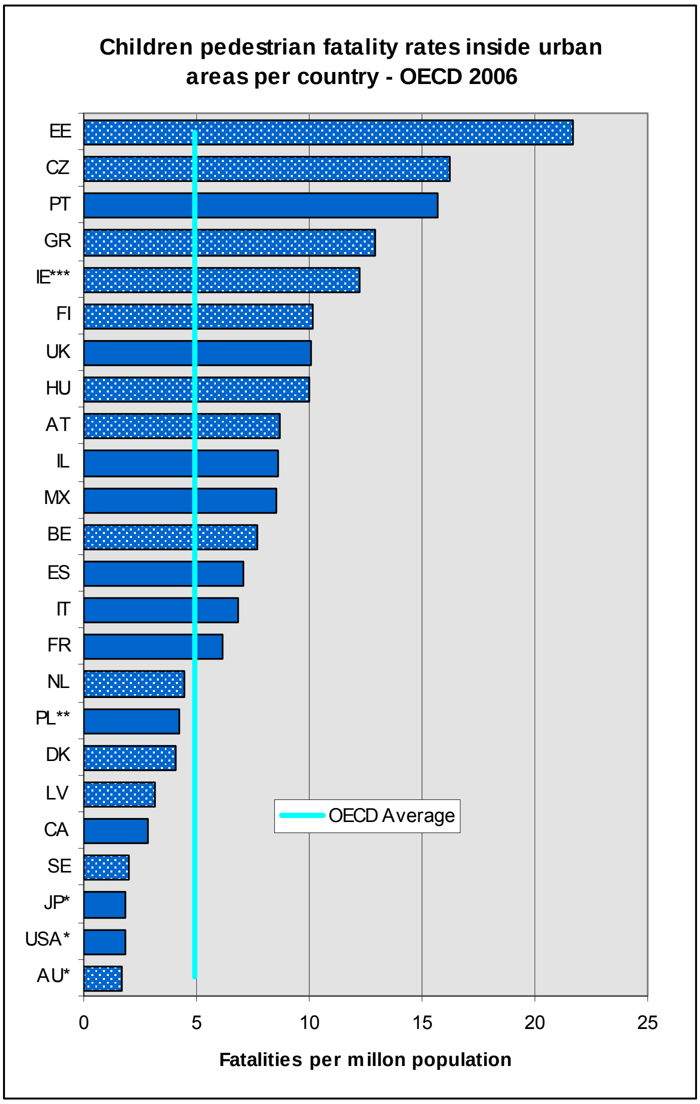
Source: CARE database / OECD database / Eurostat (date of queries: September 2009) * Data for year 2008, ** Data for year 2005, *** Data for year 2003

In Canada, senior pedestrians (those aged 65 or older) have the highest risk of being killed in a traffic crash. In 2004-06, 34% of pedestrians killed were seniors, even though seniors accounted for only 13% of Canadians. In the United States, in 2008, the fatality rate for pedestrians older than 65 was 2.07 per 100 000 population – higher than for any other age group.

In Japan, the situation is very particular (see Figure 8), as the population is older than in most other OECD/ITF countries, with 22% of the population above 65. Around 60% of people aged 65 and above do not have a driving licence, which means that they travel using modes other than cars, including bicycle and walking. In terms of distance travelled (check), pedestrians are more at risk than other road users; In addition, the risk of a pedestrian aged 65 and more to be killed in a traffic accident is more than twice those of the general population. In the coming years, it is expected that the number of pedestrian killed among the 65 and above will significantly decrease, because the age group below will be able to drive.

Greece, Austria and the UK present increased fatality rates for elderly pedestrians inside urban areas in relation to other countries, compared to their respective total rates. On average, 25 elderly pedestrian fatalities per population are observed in urban areas in the examined OECD countries.

Figure 9 Children pedestrian fatality rates (fatalities per million population) inside urban area per country, OECD - 2006



Source: OECD/ITF / CARE / Eurostat (date of queries: September 2009) * Data for year 2008, ** Data for year 2005, *** Data for year 2003 Notes: EU countries fatality data are 2003-2006 averages. Dotted bars indicate small sample of fatalities.

Children

On average, 5 children pedestrians per million inhabitants were killed in road accidents inside urban areas in the examined OECD countries in 2006 (Figure 10). Finland, Austria and the UK present increased children pedestrian fatality rates, compared to their total fatality rates, whereas Japan and Mexico present reduced children pedestrian fatality rates, compared to their total fatality rates in urban areas. It is underlined that, due to the small sample of children pedestrian fatalities inside urban areas, the average number of fatalities was taken for the EU countries (i.e. for those for which the data was available) for the period 2003-2006. Nevertheless, the children pedestrian fatality rates should be considered with particular caution.

Recent data show that that children's risk is much less than for some other groups. The 0-14 age group represents 15-20% of the population and in most countries less than 6% of pedestrian fatalities (see Table 6). The road safety of children has actually improved in most countries, through the adoption of a package of measures (school routes, speed management, variable speed limits, training, etc.). In Canada, in 2004-06 children under the age of sixteen made up about 19% of the Canadian population, they accounted for only 6% of pedestrians killed in traffic collisions

However, the number of children fatalities is still too much and traffic is a major threat for the youngest. In the United States, in 2008, nearly one fifth of the children between the ages of 5 and 9 killed in traffic crashes were pedestrians.

Finally, it is noted that these differences among countries in children and elderly pedestrians' accident involvement may be attributed to differences in exposure of these particular groups, partly affected by weather conditions, as well as by other factors such as the country's residential and traffic infrastructure and the typical national habits (e.g. adults accompanying children to school etc) (Oxley et al. 1997; Rosenbloom et al. 2008).

	0-14 age group	
	% in population	% in pedestrian fatalities
Australia	19%	4%
Austria	15%	4%
Czech Republic	14%	3%
Denmark	18%	10%
Finland	17%	6%
France	18%	6%
Germany	14%	4%
Japan	13%	3%
Netherlands	18%	5%
New Zealand	21%	13%
Norway	19%	6%
Spain	15%	5%
Sweden	17%	2%
Switzerland	16%	5%
United Kingdom	18%	9%
United States	20%	6%

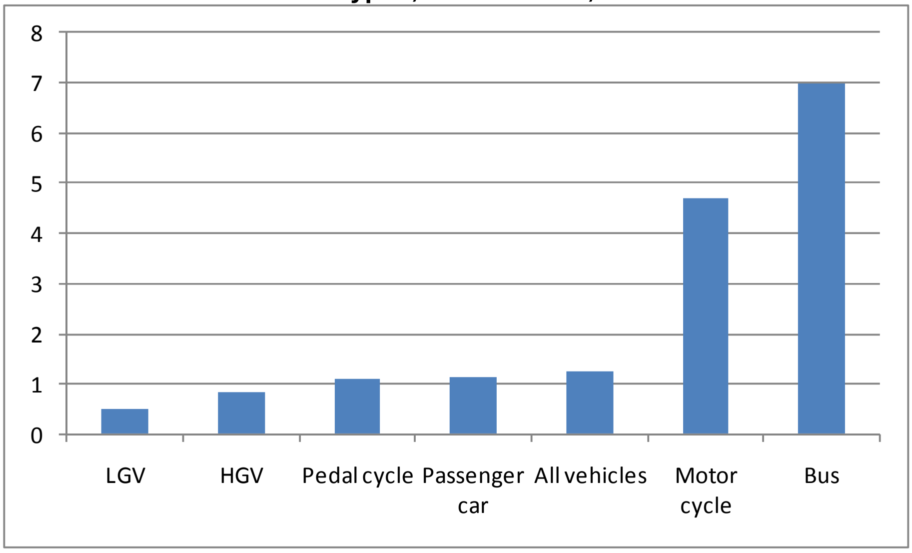
Table 13 Percentage of children in population and in pedestrian fatalities
Source: OECD/ITF, 2010

Collision opponents

Most of pedestrians are hit by passenger cars or light duty vehicles. This is because cars form the majority of traffic. However, when allowing for distance travelled, motorcycles and buses pose greater risk to pedestrians in urban areas (see Figure 11 from Great Britain). Usually, pedestrians are hit by passenger car or light duty vehicles.

In Greece, pedestrian fatalities inside urban areas for 2008 were associated by 56% with passenger cars, and by a considerable 18% with motorized two-wheelers (mopeds and motorcycles). Such figures may be the case also in other (e.g. Southern European) countries with increased traffic of two-wheelers.

Figure 10 Reported killed and serious injured pedestrian casualty rate per billion veh-km by vehicle types, Great Britain, 2008.



Source: Department for Transport, United Kingdom.

Point of impact on the vehicle

The majority of pedestrian fatalities (84%) in Australia involve the pedestrian being struck by the front of the vehicle. About 35 % of pedestrians are struck by the front left of the vehicle, which is the side nearest the kerb in Australia. About 25 % are struck by the centre of the front and 25 % by right front, which is nearest the centre of the road. The only exception to this is where an articulated truck is involved. About two thirds of these crashes involve an impact somewhere other than the front of the vehicle.

The majority of pedestrians (94%) do not strike the undercarriage of the vehicle. They are thrown over or to the side of the vehicle on impact. The point of impact on the vehicle is not related to the type or extent of injuries received in fatal crashes, the speed of the vehicle, the propensity to brake or swerve or driver responsibility for the crash. Bull bars were involved in 12 % of fatal pedestrian crashes. However, the proportion of missing data for this variable is 55 % of the total cases. It is probable that bull bars are involved in up to 20 % of pedestrian fatalities.

4.3. Accident causation factors, fault and responsibility

Around one in three fatally injured pedestrians was hit by a driver who committed at least one driving infraction prior to the crash such as speeding, drinking, failure to yield, ignoring traffic controls, etc. However, drivers are not always to blame when a pedestrian is killed in traffic. Dangerous pedestrian behaviours such as crossing an intersection without the right of way, running into the road, or walking on the pavement can, and often do, result in pedestrian

fatalities. The most frequent at-fault behaviour, crossing an intersection without the right of way, accounted for about 13% of all pedestrian traffic deaths (Canada).
Table 7 illustrates for Great Britain the main contribution factors of crashes. In half of the cases, contributory factors were only assigned to pedestrians (with pedestrian failed to look properly being the most common individual factor). In 21% of crashes, factors were only associated with vehicles involved (with failed to look properly being the most common vehicle factor. In the remaining 25% at least one factor was assigned to both a pedestrian casualty and a vehicle (with the most common combination being both participants falling to look properly).

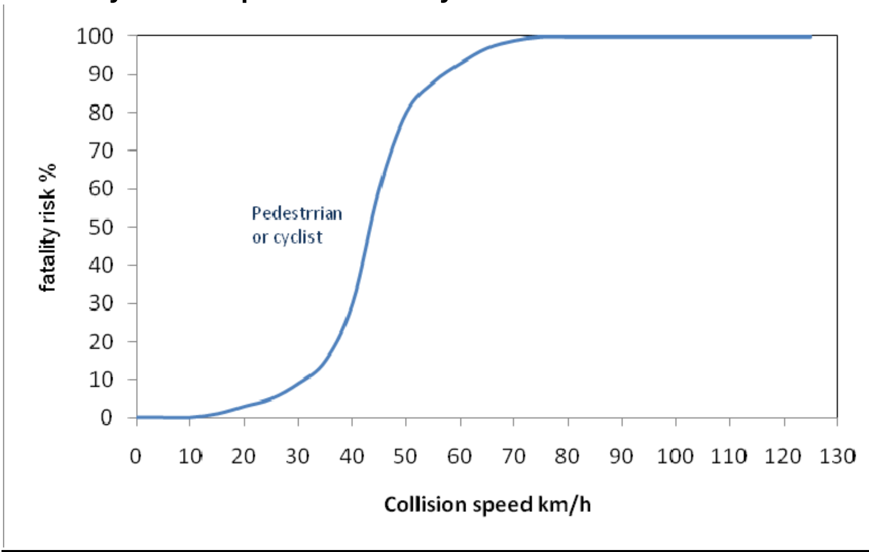
Contributory factor	Factor assigned to:	Fatal		Fatal and serious		All severities	
		Number	*Per cent*	Number	*Per cent*	Number	*Per cent*
Pedestrian failed to look properly	Pedestrian	249	*46*	3,295	*58*	12,152	*60*
Pedestrian careless, reckless or in a hurry	Pedestrian	49	*9*	1,196	*21*	4,757	*23*
Failed to look properly	Vehicle	128	*24*	1,106	*19*	4,232	*21*
Pedestrian crossing road masked by vehicle	Pedestrian	51	*9*	990	*17*	3,700	*18*
Pedestrian failed to judge vehicle's path or speed	Pedestrian	130	*24*	1,072	*19*	3,551	*17*
Pedestrian impaired by alcohol	Pedestrian	79	*15*	783	*14*	2,340	*11*
Careless, reckless or in a hurry	Vehicle	40	*7*	398	*7*	1,443	*7*
Dangerous action in carriageway (eg. playing)	Pedestrian	52	*10*	410	*7*	1,367	*7*
Vision impaired by stationary or parked vehicle(s)	Vehicle	12	*2*	303	*5*	1,198	*6*
Pedestrian wrong use of pedestrian crossing facility	Pedestrian	28	*5*	271	*5*	1,012	*5*
Number of accidents		537	*100*	5,676	*100*	20,348	*100*

Source: Department for Transport, United Kingdom

Table 14 Contributory factors for reported accidents involving pedestrians

Information from France shows that in case of a crash with pedestrians, pedestrians are responsible in 21% of the cases, and the drivers of the opponent vehicle in 47% of the cases. Pedestrian responsibility is more often assigned in accidents involving motorcycles and accidents involving trucks. Assuming that the pedestrians involved in the various types of accidents have the same characteristics, one can conclude that pedestrian adapt less well to some conditions.

Figure 11 Fatality risk of a pedestrian hit by a car as a function of the collision speed



Source: Wramborg (2005)

Speeding
Pedestrian injury severity is directly linked to the impact speed when hit by a vehicle. It is now recognized that at an impact speed superior to 30 km/h, a pedestrian has very little chance to survive following a crash.

Alcohol involvement

Alcohol involvement - either for the driver or for the pedestrian - is an important factor of fatal crashes. In many countries, it is compulsory to test the crash opponents (drivers, pedestrian) in case of an injury crash. In practice, pedestrians are only tested in fatal crashes (when countries allow tests on dead bodies).

In the United States, alcohol was a contributing factor in 48% of pedestrian fatal road accidents. Of the pedestrians involved, 36% had a BAC at 0.8 g/l or higher. Of the drivers involved, 13% had a BAC of 0.8 g/l or higher, less than one half the rate of pedestrians.
In France, fatal pedestrian crashes involved drunk drivers in 16% of case and a drunk pedestrian in 19%of the cases.

4.4. Social costs of pedestrian crashes

It is not an easy task to assess social costs of road crashes; and it is even more difficult to assess the social costs of road crashes involving pedestrian crashes.

As an example, in New Zealand, it is estimated that road crashes involving pedestrians costs society around NZD 300 000 annually. Part of the high costs relates to the relative severity of many pedestrian injuries. On average, pedestrians who are hospitalised cost twice as much to treat as hospitalised motor vehicle occupants (Langley et al, 1993).

4.5. Methods and best practices for detailed pedestrian safety data analysis

The results presented in the previous section are based on the harmonized data available in international databases (e.g. CARE, IRTAD) and provide only an overall picture of general trends and figures. In order to obtain more detailed results on pedestrians safety in urban areas, one has to explore national road accident databases, which include the more detailed information collected by the Police. This data may not be comparable between countries, given that the national definitions of variables and values, as well as the degree of national under-reporting, often differ significantly.

On the other hand, such analyses may provide more insight on pedestrian accidents in urban areas, by revealing specific factors and patterns, and eventually allowing addressing specific problems. In general, analyses performed at national level are much more detailed and explanatory, as they are based on information available in disaggregate form, allowing the analysis of individual accidents.

A family of pedestrian analyses is based on in-depth accident investigations; this data is collected by groups of experts and are typically not available in the national databases, as these include Police records. The added value of using in-depth road accident investigation data in pedestrian safety analyses is twofold; first, a number of variables seldom available in national road accident data files can be made available by in-depth road accident investigations, especially on complicated and often underreported issues vehicle manoeuvre, chain of accident events, fault etc. Secondly, data quality may be significantly improved through in-depth data collection techniques (Dupont and Martensen, 2008).

Several countries maintain official in-depth accident investigation databases and their usefulness has been demonstrated by their exploitation at national level (Larsen & Kines, 2002; Fleury & Brenac, 2001). However, no uniform and comparable data are available at European level. Within the SafetyNet project of the 6th Framework Programme of the European Commission, an in-depth database was created on the basis of fatal accident investigations and preliminary analysis of this data revealed important pedestrian accident characteristics. The more systematic collection of in-depth accident investigation data at international level may thus offer new potential for dealing with pedestrian safety issues.

Such data are used since the early 70s in the USA for analyzing pedestrian accident patterns. These resulted in the development of distinct accident type classifications, relevant to countermeasure implementation (Snyder and Knoblauch, 1971). Since then, pedestrian accidents are routinely classified according to these types on the basis of causal factors and target groups, to provide a basis for countermeasure identification. The five most frequent types account on average for over 50% of all pedestrian accidents (Stutts et al. 1990). These accident types are regularly updated and the related results are published in the Traffic Safety Fact Sheets of the NHTSA.

Accident scenarios, including pedestrian accidents, were also developed in France on the basis of in-depth investigation methods or on detailed analyses of police reports (Brenac & Megherbi 1996). The "prototypical scenarios" contain groups of accidents which are homogeneous as regards the phenomena and possibilities for prevention. More specifically, each accident is decomposed into several phases, namely:

- the situation prior to driving,
- the driving situation, i.e. driving conditions and actions on road upstream the accident location,
- the accident situation; this is characterized by an event and/or kinematic factors which mark the transition to a critical situation,
- the emergency situation where only extreme manoeuvres (in dynamic terms) could still, in certain cases, avoid a collision,
- the impact situation, including the impact itself and its consequences.

This is addressed in the next section.

Another promising detailed analysis technique is based on collision opponent analysis, in which accidents are analyzed on the basis of opponent types (e.g. single vehicle accidents, car-motorcycle, car-pedestrian, motorcycle-pedestrian and so on). Stipdonk and Berends (2008) showed that for pedestrian-car and pedestrian-motorcycle accident types the victim is practically always the pedestrian. This is confirmed by Dupont and Martensen (2008). In both studies, it is underlined that in all accidents, but especially in pedestrian accidents, fatality and injury risk are significantly affected by the characteristics of the opponent. Such analyses though can only be performed on the basis of national data (i.e. disaggregate Police records) or in-depth accident investigation data.

Finally, pedestrian behaviour surveys are implemented in some countries in order to analyze behavioural patterns, identify factors related to risk-taking behaviours and understand vehicle / pedestrian interactions. These analyses provide important additional insight on pedestrian safety problems in urban areas.

Consequently, it is deduced that national road safety data, either disaggregate Police data or in-depth accident investigation data, can be far more insightful in analyzing pedestrian safety issues, but these analyses are bound to be limited at national level. Moreover, even if the detailed advanced techniques described above are not applied, the national data include an important amount of additional information than what is forwarded to the international databases. This type of analyses may be performed for the understanding of accident mechanisms and the identification of pedestrian accident patterns, which may be linked to specific policies and actions.

4.6. Pedestrian Accident types

4.6.1. Case studies: Typical accident scenarios in France

In the 80s the *French National Institute for Transport and Safety* (INRETS) developed the definition of “typical accident scenarios”: this technique is based on the analyse of Police accident reports occurred in an area, in order to classify their temporal and casual development, describing the different phases of the crash. Every group of accidents which have particular similarities constitutes a scenario, and for every scenario some solutions are proposed.

Concerning pedestrian accidents, study of 189 Police accident reports conducts to 20 typical accident scenarios (Brenac, Nachtergaele et Reigner, 2003[14]). Theses scenarios have been tested on 185 another Police reports, it could be estimate that theses scenarios could account for 85 % of pedestrian accidents reported by French Police.

Four main categories of pedestrian accident scenarios could be noticed. As far as possible, we illustrate these categories with pedestrian crash types figures from Snyder & Knoblauch (1971). The categories are: accidents during crossing, accident on pavement out of crossing, accident where pedestrian is ‘collateral damage’ and lastly, ‘particular context’.

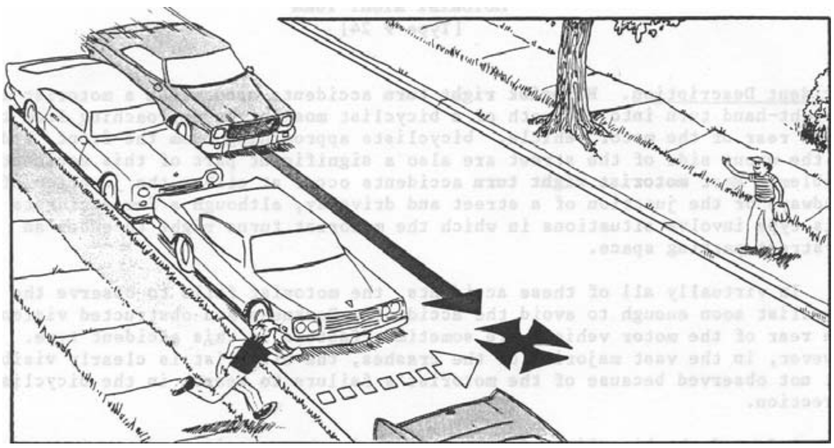
1. Accident during crossing

The main category concern pedestrians who cross the pavement or go into the pavement. This category involves the majority of pedestrian crashes. This “crossing” category can be divided into two sub-categories: detection problem .and anticipation problem

Detection problem

The first one shows a great influence of visibility obstruction or poor visibility condition. Pedestrians cross but are even initially masked by parked vehicles, or masked during crossing by stopped vehicles on the first lane crossed. In some of the accidents, poor visibility of pedestrians is due to weather conditions (rain or night).

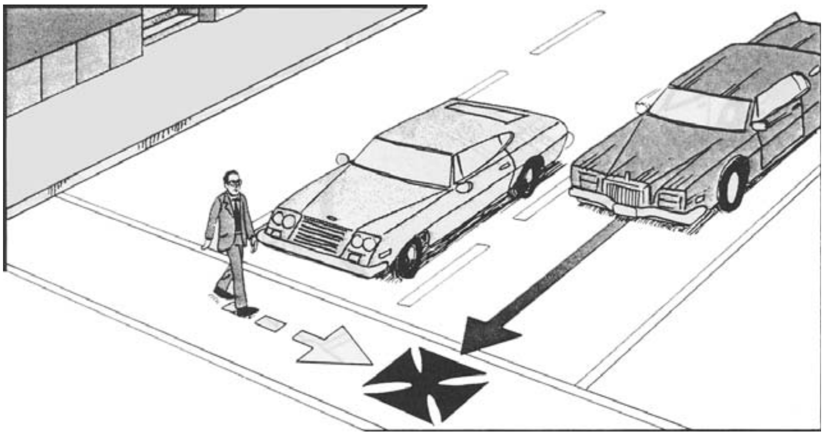
A vehicle travels in urban area on a main street, which is often particularly wide and generally not in intersection. A pedestrian (often a young child, accompanied by parent or peer) prepares to cross the street outside a pedestrian crossing.



[14] Brenac, T., Nachtergaële, C., & Reigner, H. (2003). Scénarios types d'accidents impliquant des piétons et éléments pour leur prévention. Rapport n°256. Arcueil: Les collections de l'INRETS.

The pedestrian, initially hidden, generally by an immobile vehicle, undertakes his/her crossing when the vehicle arrives, often while running when it's a child.
The driver did not perceive the pedestrian, or perceived him/her very late. The pedestrian did not perceive the vehicle.

A vehicle travels in urban area, on a main street, usually a commercial street. A pedestrian prepares to cross the street, usually at an intersection or near of an intersection. The traffic is dense or very dense and the roadway is often wide.
The pedestrian takes advantage of a stop of vehicles on one or several traffic lanes and undertakes his/her crossing, often in a hurry, between or in front of stopped vehicles (or slowly moving). He arrives on a part of the roadway on which a vehicle travels. Mutually perception generally comes very late because of one of the stopped vehicles (or slowly moving), generally in a queue of vehicles waiting in an intersection or in a traffic jam, which constitutes a sight obstruction.
In general, the driver does not have time to undertake an emergency manoeuvre and the vehicle knocks down the pedestrian.



Brenac et al. (2003) pointed out different measures to prevent this kind of accident:

- different means of speed reduction. Speed plays an important role in this kind of scenarios, because it conditions time available for driver, when driver sees pedestrian, to react before collision;
- city planning, in particular parking organization and practices. Parking should permit to clear zones with good reciprocal visibility between drivers and pedestrians. Bus stop should be also built in order to avoid visibility masks created by stopped buses.
- reduction of street width. Most of the time, pedestrians seek information before crossing. This perception task is often difficult because street is too wide, with too lanes and complex planning. Reducing street width can improve perception task and speed reduction. This width reduction can be accompanied with creation of central islets. These both elements seem to reduce pedestrian accident risk[15];
- driver's formation. Limited experiment for driving has effect on driver's detection and anticipation skills[16]. In this case, formation of expectations about potential presence of hidden pedestrians is probably more frequent among experienced drivers, these

[15] Zeeger, C.V., Stewart, J.R., Huang, H. & Lagerway, P. (2001). Safety effects of marked versus unmarked crosswalks at uncontrolled locations, analysis of pedestrian crashes in 30 cities. Transportation research record, 1773, 56-64.

[16] Edgerink, H.O., Lourens, P.F. & Van der Molen, H.H. (1986). Driving strategies among younger and older drivers when encountering children. Accident Analysis and Prevention, 18(4), 315-324.

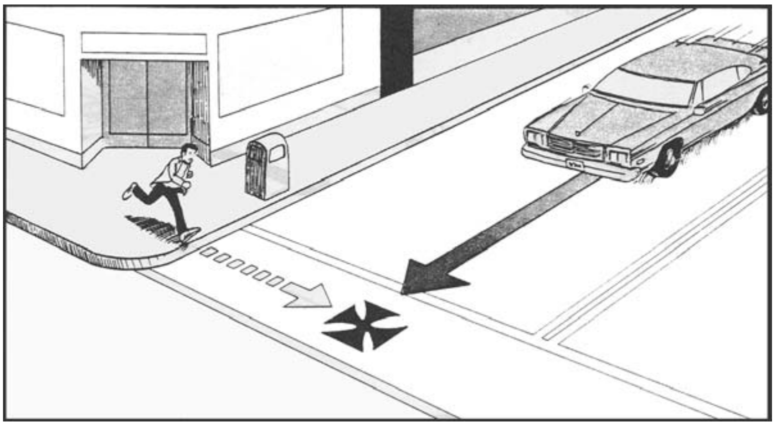
expectations favour speeder detection when a pedestrian really suddenly appears. These kind of situations could be integrated in driver's formation[17]

- young pedestrian's education. This kind of scenario highlight problem with detection strategy. Sometimes pedestrians do not look at traffic, but sometimes pedestrians look but fail to see incoming traffic. In these cases, learning to younger pedestrians (below 9 year-olds) to stoop and look at the "line of vision" (line where visibility is clear) could have significant effect on crossing behaviours[18];
- parents' education. Young pedestrians' supervision plays on important role in this kind of scenarios, where young pedestrian often crosses to join someone else on the other side of the street. Possibility to modify adults' behaviours with young pedestrian by actions in associative groups should be taken into account with experiment of this kind of situation.
- action for older pedestrians: local action combining information and education with planning measures could be effective[19].

Anticipation problem

The second sub-category concerns driver detection or anticipation problems. Anticipation problem arises when pedestrian is detected on the sidewalk by the driver but the driver do not anticipate pedestrian crossing, which surprises driver.

One vehicle travels in built-up area, generally outside intersection and zebra crossing, and on a main street. A pedestrian (often young pedestrian) is on the sidewalk, often with other pedestrians when the first one is young. The pedestrian is generally detected by the driver.
The pedestrian begins to cross, without paying attention to traffic and often while running when it's a young pedestrian, or suddenly dash on the pavement, whereas driver, who did not anticipate pedestrian's manoeuvre, did not slow down. Pedestrian's attention is often focused on another pedestrian on the opposite sidewalk or on a particular context.



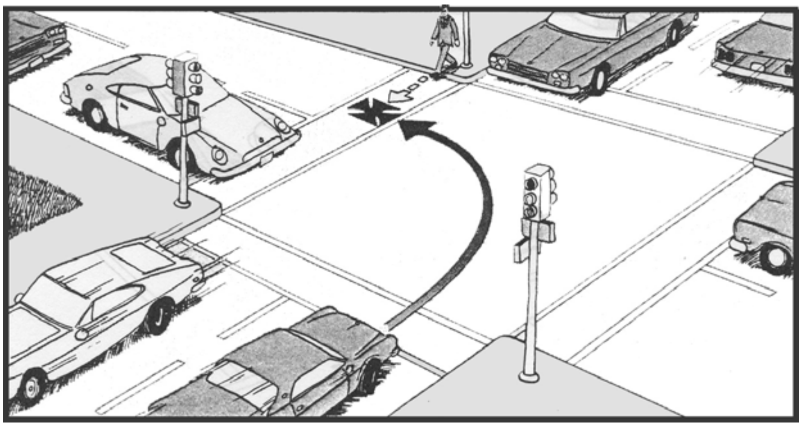
Anticipation problem occurs when driver's attention is focused on traffic and driver "look but fail to see" pedestrian.

[17] Fischer, D.L., Laurie, N.E., Glaser, R., Connerney, K., Pollatsek, A., Duffy, S.A. & Borck, J. (2002). Use a fixed-base driving simulator to evaluate the effects of experience and PC-based risk awareness training on driver's decisions. Human Factors, 44(2), 287-302.

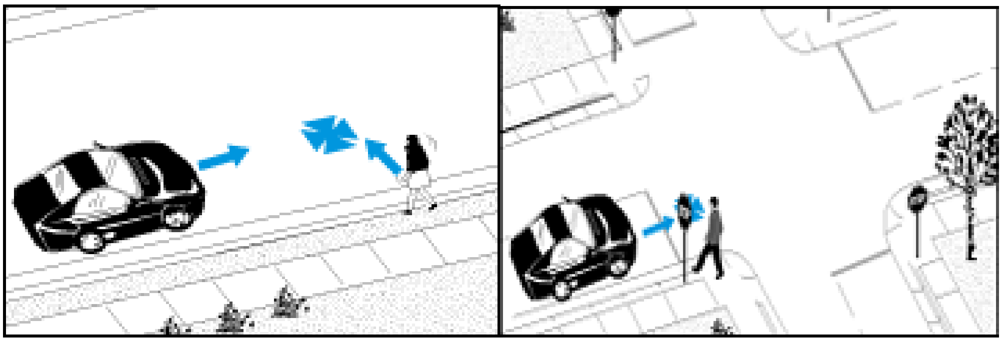
[18] Duperrex O., Bunn, F., Roberts, I. (2002). Safety education of pedestrians for injury prevention: a systematic review of randomised controlled trials. British Medical Journal, 324, 1129-1131.

[19] Blomberg, R.D. & Cleven, A.M. (1998). Development, implementation and evaluation of a pedestrian safety zone of elderly pedestrians. Report DOT-HS-808-692. Washington, DC:NHTSA.

Vehicle travels in built-up area in a generally large intersection. It came from a main street and get ready to turn left or right in another street. A pedestrian, often elderly, begin to cross the destination street of the vehicle, generally on a zebra crossing.
Driver makes manoeuvre for changing direction, whereas pedestrian continues or begins to cross. More often the driver did not see the pedestrian, or too late.



A vehicle travels on a large or a fast street in a urban area. A pedestrian, often young or elderly, is waiting or beginning to cross, generally on a zebra crossing, often with traffic light.
The driver does not slow down, whereas pedestrian is crossing and the pedestrian light is green. Generally, pedestrian has detected the vehicle, but judge it's far enough or think it will slow down or stop, because of the zebra crossing and the traffic light. Driver detects pedestrian too late or think that he/she will stop her/his crossing.



Brenac et al. (2003) pointed out different measures to prevent this kind of accident:

- speed reduction. Speed conditions time driver has to react. Furthermore, high speed on some urban axes constitutes a strength ratio very favouring drivers and therefore contributing to the development of inappropriate expectations in an urban environment;
- urban street planning: Street planning should not conspicuously privilege cars instead of pedestrians. Planning should clearly explicit non motorized use of public space, should facilitate pedestrian crossings and underline crossing sites, mostly on intersections. These elements should develop better adapted expectations among drivers. Furthermore, traffic lights seem to be a negative element in this kind of scenarios, with green lights giving to drivers a feeling of priority. Planning should therefore not combined priority and high speed[20]: some solutions like elevated pedestrian crossings with traffic lights on intersection could have positive effects in this case.
- organization of traffic lights. In intersections between four lanes, organization of traffic lights in 3 phases limits risk of accident between pedestrian and turning vehicle. In

[20] SETRA, CETUR (1992). Sécurité des routes et des rues. SETRA, CETUR, La documentation française.

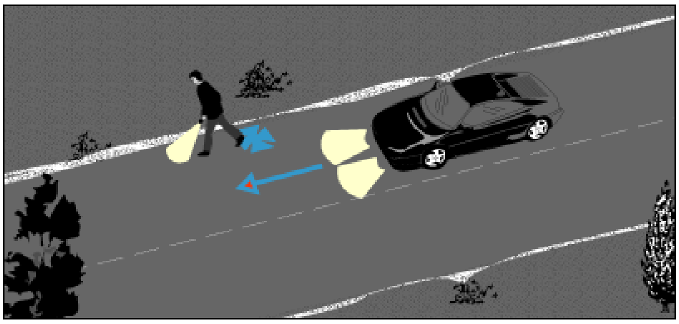
organization in 3 phases, turning vehicles are no more confronted to traffic in front and can then be more focused on crossing pedestrians[21]

- driver's formation. Limited experiment for driving has effect on driver's detection and anticipation skills[22]. In this case, formation of expectations about potential presence of hidden pedestrians is probably more frequent among experienced drivers; these expectations favour speeder detection when a pedestrian really suddenly appears. These kinds of situations could be integrated in driver's formation[23],
- pedestrian education. In this kind of accident, pedestrians sometimes are overconfident in the "protection" offered by pedestrian crossing, and eventually traffic lights colours. Therefore, sometimes pedestrians do not take any information on traffic, sometimes make wrong anticipation on drivers' behaviours, and sometimes look at traffic before crossing but not after beginning crossing (car is then not detected). More defensive practices, taking account of errors that drivers could make in pedestrian's detection and necessity of constantly look at traffic should be educated.

2. Accident on pavement out of crossing

The second main category of typical accident scenarios concerns pedestrians staying or walking on the pavement, or pedestrians going out vehicles. One part of these scenarios involves pedestrians who are not been detected by the driver, often due to weather conditions (night) in contexts where pedestrians' presence is not anticipated by the driver (outside built-up areas).

A vehicle travels by night outside built-up areas, 1/ even on a large road with sober driver and drunk pedestrian, 2/ or on a narrower road with drunk driver and sober pedestrian, 3/ or on a highway. Pedestrian 1/ walks on the pavement, back on the traffic, even on the middle of the large road, or on the side of the narrower road 2/ or stay or walk near a stopped vehicle.
Vehicle speed is too high; driver does not detect the pedestrian, or too late, when he/she are seen due to the headlights.

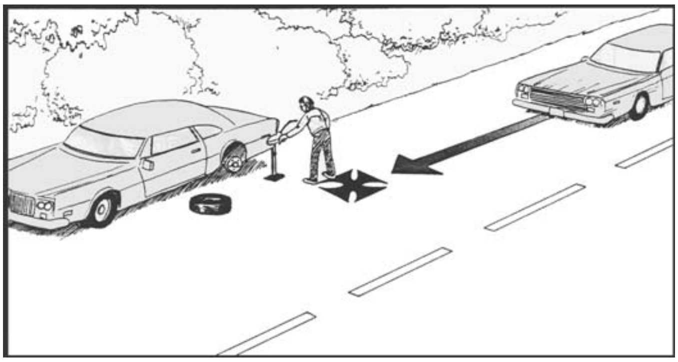


Another part concerns pedestrians which surprise driver, by moving on pavement or by going out a vehicle, without paying attention to traffic. The last scenario of this category concern pedestrian shock by reversing car, when neither the driver, nor the pedestrian take each other into account.

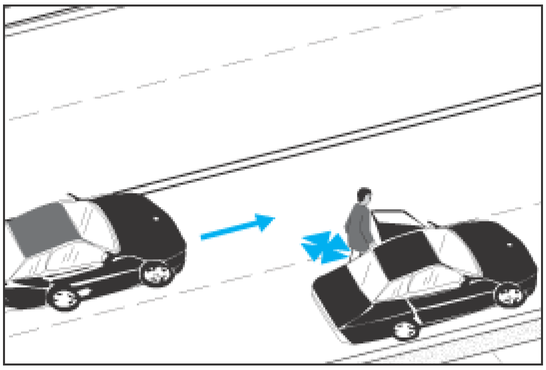
[21] Hall, R.D. (1986). Accidents at four-arm single carriageway urban traffic signals. Contractor report 65. Crowthorne: TRRL.

[22] Edgerink, H.O., Lourens, P.F. & Van der Molen, H.H. (1986). Driving strategies among younger and older drivers when encountering children. Accident Analysis and Prevention, 18(4), 315-324.

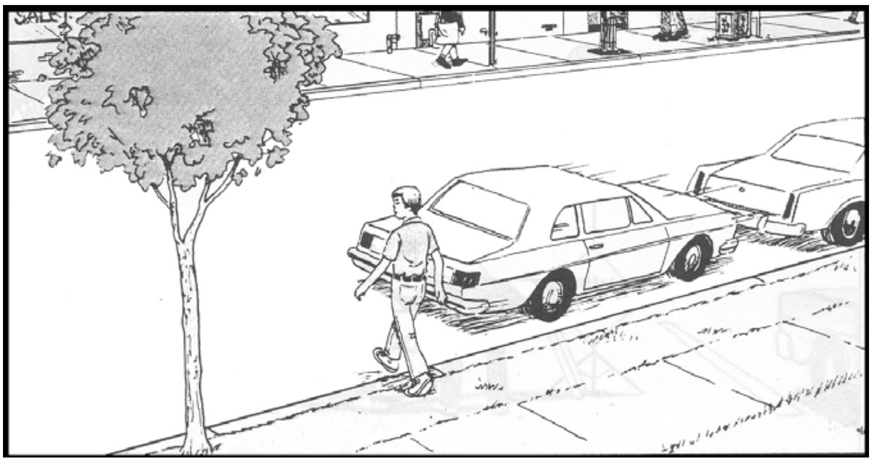
[23] Fischer, D.L., Laurie, N.E., Glaser, R., Connerney, K., Pollatsek, A., Duffy, S.A. & Borck, J. (2002). Use a fixed-base drinving simulator to evaluate the effects of experience and PC-based risk awareness training on driver's decisions. Human Factors, 44(2), 287-302.



A vehicle travels in a built-up area in a street with low traffic density. A pedestrian stay on the pavement, or near the pavement, while discussing with someone else, or is sit in a vehicle stopped on the side of the pavement. The pedestrian moves back or turn back to cross, or go out of the vehicle while the vehicle approaches. The driver does not anticipate pedestrian's movement or does not detect the pedestrian and pedestrian's attention is focused on the discussion.



A driver begins to leave a parking place or wants to park. A pedestrian, often elderly, moves in a zone in the back of the vehicle. Driver reverses, whereas pedestrian, which has not been detected by the driver, moves or stays in the back of the vehicle.



3. Accident where pedestrian is a "collateral damage"

The third main category of pedestrian typical accident scenarios concerns situation when there is no interaction between driver and pedestrian before accident. Vehicle manoeuvre in emergency or conflicted situation causes pedestrian accident and pedestrian could be on or out of the pavement.

4. Particular context

The last category of scenarios concerns pedestrian accident hit by a cyclist or a rider on a sidewalk or a lane forbidden to vehicles or pedestrian accident hit by a vehicle after a verbal conflict with the driver.

4.6.2. Other international data on accident crash types

United States
In order to compare these pedestrian crash types in two countries, we analyse FHWA data[24] for crash type rates in the USA in the light of the French typical accident scenarios.

Accident type	Percentage of cases
Al Dart-outs and dashes	31.7%
Dart-out first half	11.8%
Dart-out second half	5.3%
Pedestrian strikes vehicle	11.0%
Intersection dash	4.2%
A2 Other typical pedestrian situations	0.9%
Multiple threat situation	8.4%
Pedestrian waiting to cross in roadway	0.4%
Vehicle turn/merge with attention conflict	2.0%
Multiple pedestrian split	1.2%
B Situations with specific predisposing factors	3.4%
Vendor-ice cream truck	2.3%
Pedestrian exiting from vehicle	1.2%
Bus stop related	0.2%
Backing up	1.4%
C Non-street locations	1.2%
Non-pedestrian activity not in roadway	2.9%
Freeway-expressway-from car	1.5%
Freeway-expressway-crossing	0.4%
Off-street parking	0.6%
D Atypical pedestrian activity	1.6%
Non-pedestrian activity in roadway	1.5%
Pedestrian walking in roadway	1.2%
Working on vehicle	0.1%
E Miscellaneous	3.4%
Rear wheel: truck or bus	0.6%
Weird	59.7%
F Atypical causes (not pedestrian countermeasure corrective)	13.9%
Precipitated by illegal antisocial act to pedestrian	8.8%
Precipitated by illegal antisocial act by pedestrian	4.0%
Hot pursuit	4.8%
Result of auto-auto crash	2‘2%
Driverless vehicle	6.7%
Total	100.0%

Source: M. B. Snyder and R. L. Knoblauch (1971)[25].

Table 15 Classification of pedestrian injury events

[24] Stutts, J., Hunter, W. W., & Pein, A. (1996). Pedestrian Crash Types: 1990s Update. *Transportation Research Record, 1538*, 68-74.

[25] Snyder, M. B., & Knoblauch, R. L. (1971). *Pedestrian safety: the identification of precipitating factors and possible countermeasures.* Washington, D.C.: Operations Research Inc. for National Highway Traffic Safety Administration.

It should be noted that crash type involving detection problem is far more frequent in France than in USA. On the other hand, lack of anticipation, from the driver or the pedestrian, seems to be a bigger issue in the USA. This issue may be due to low pedestrian presence in USA's streets, whereas the same streets seem to create lower problem of pedestrian detection comparing to French ones. Thus, pedestrian accident crash types vary according to urban design and pedestrian mobility across countries.

In Australia
In Australia data, the coroners' records contain details of whether the vehicle braked or swerved prior to the crash. This information is summarised in the accompanying table. A substantial number of vehicles neither braked nor swerved. For Australian Federal Office of Road Safety, this is probably indicative that the driver had little or no time to react, rather than lack of attention on behalf of the driver. Apparently, pedestrians' movements in crossing the road or walking along it are such that in number of cases drivers had no time to brake or to swerve. The relatively low proportion of drivers found at fault on the basis of coronial evidence supports the interpretation that it is action on part of the pedestrian which is crucial. It is interesting that approximately the same proportion of drivers "braked only" as "braked and swerved" possibly reflecting the traffic conditions at the time of the crash.

	Number	Percentage
Braked only	63	**20%**
Swerved only	13	**4%**
Braked & swerved	68	**22%**
Did not brake or swerve	131	**42%**
Unknown	38	**12%**

Table 16 Braking and Swerving Prior to Pedestrian Crash (1992)

Belgium
Belgian Institute for Road Safety made an analysis on pedestrian accident on unregulated zebra crossing on mid-block sections, intersection and roundabout.

On the 34 pedestrian accidents analysed in mid-block, 65 % occur on road favouring high speed, with too high crossing length. In 53 % of cases, reciprocal visibility between driver and pedestrian were insufficient, in 41 % of cases, pedestrian was masked by parked vehicles. These data highlight large detection issue in mid-block crossing.

On the 33 pedestrian accident analysed in intersection, 42% occur on intersection where pedestrian have to cross more than 10 meters in one time. 76% of cases occur on road favouring high speed. 24% of cases are linked on pedestrian detection, masked by parked vehicle. 70% of accident occur in conditions where driver fail to see the pedestrian after crossing straight on or turning right or left in intersection. Thus, it seems that anticipation issue (look but fail to see) is the biggest problem in pedestrian accident in intersection.

On the 36 cases of pedestrian accident analysed on roundabout, 55% occur during driver's exit of the roundabout. 28 % occur on central ring and 22% during driver's entry on the roundabout. In all cases, accident seems to be due to driver's look but fail to see issue concerning pedestrian.

On intersection and roundabout, major problem for pedestrians seems to be that driver is focused on traffic insertion task and on other vehicles. Therefore, driver does not see pedestrians, even when they are crossing on zebra crossing.

5. Conclusions

Official road accident statistics, based on police crash reports, underestimate injuries to pedestrians and bicyclists due to an underreporting of events that do not involve a motor vehicle, those that occur off the public roadway, and/or those that result in relatively less serious injuries.

While accident crash data provide considerable information to help guide safety program and countermeasure development, they have often been referred to as "the tip of the iceberg" because they are limited almost entirely to motor vehicle-related events that occur on public roadways. Specifically, they exclude: (1) many pedestrian-motor vehicle crashes that occur in non-roadway locations such as parking lots, driveways, and sidewalks, and (2) pedestrian falls that do not involve a motor vehicle, regardless of whether they occur on a roadway or in a non-roadway location. There is also evidence that even many pedestrian-motor vehicle collisions occurring on public roadways are not reported in police crash files.

Estimating the total number of injured pedestrians in traffic is not a simple task, estimating the number of injured pedestrian in non traffic accident is even more challenging. There is a clear lack of data on the magnitude of this social and health problem.

As the transport sector has its main focus on road traffic injuries (injuries involving a moving vehicle) the definition of vulnerable road users used by the road traffic sector excludes falls in pedestrians and injuries to other non-motorised road users such as inline skaters or wheelchairs on public roads. These injuries receive little recognition and have, therefore, not been included in systematic preventive activities of the road traffic sector so far.

Further attention is necessary from public health to provide good information systems that allow to monitor morbidity and mortality and understand the patterns of falls among pedestrians and to develop preventive interventions

Traffic accident

As regards macroscopic pedestrian safety data, these are gathered and stored by several international organisations; they are processed so that they can be comparable across different countries, by applying common definitions and collection procedures on the national data for a relatively limited number of basic variables. Nevertheless, issues such as pedestrian injury definitions and under-reporting remain to be adequately addressed in the international databases. The use of hospital data may be quite promising towards this objective. Moreover, the general lack of pedestrian mobility / exposure data at the same level of comparability does not allow for full exploitation of international pedestrian safety data.
The macroscopic pedestrian safety data are required and useful for monitoring overall trends and figures, as well as for setting priorities for policy making.

On the other hand, national road accident databases include a richness of information on pedestrian road traffic accidents, including person, vehicle, roadway and accident characteristics, which are however of limited comparability between countries. Therefore, the analyses carried out at national level may be much more disaggregate and explanatory. Additionally, particular techniques are used in different countries for more detailed analysis of pedestrian accidents and injuries, ranging from in-depth accident investigations, to definition of road accident scenarios. The use of exposure data, when available, is also more common in national analyses.

Detailed pedestrian safety data are required in order to understand pedestrian accident causes, mechanisms and patterns, so that specific actions can be linked to specific problems.

On the basis of the above, the following **key recommendations** can be made with respect to pedestrian safety data issues:

At international level:

- Harmonization of more variables related to pedestrian accidents in the national databases, according to standard definitions
- Harmonization of pedestrian accident and injury definitions (what is a pedestrian, a pedestrian road accident etc.)
- Use of medical data for cross-checking pedestrian injury severity in relation to a common definition
- Estimation of the degree of under-reporting of pedestrian injuries
- Establishment of an OECD knowledge database with the most appropriate measures linked with the most frequent pedestrians safety problems

At national level:

- Implementation of additional data collection schemes, namely in-depth accident investigations
- Identification of pedestrian accidents patterns and linking with specific actions
- Implementation of pedestrian behaviour and risk surveys
- More systematic collection and harmonization of pedestrian mobility / exposure data.

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Tasks of pedestrians and principles for simplification of those tasks

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'Walking is more than a simple locomotion.
It is a way to express your life style'

Summary

Walking is the most natural and simplest way of getting around. Due to the ever increasing complexity of the traffic system, it has become a mode in which a variety of tasks have to be performed. Theoretical models of task performance (Michon's hierarchical model or Rasmussen's knowledge and experience based model) are one possibility how to describe the tasks of pedestrians on various levels. What operation pedestrians have to perform is affected by various parameters like: who is the person performing the task (target group: children, the elderly etc.) and what is the reason for walking (trip purpose: leisure time trip, working trip), among other things. In addition the task performance of pedestrians can be viewed from two temporal aspects: tasks before the actual trip and tasks while the trip is performed. Pre-trip tasks are mainly carried out on a strategic level and refer to decisions on the equipment and on the route itself. Pedestrians are offered different kind of media to plan their walking trip e.g. printed maps, internet, route-planners, navigation systems etc. Tasks during the actual walking trip are of tactical pro-active or automatic operational character. During the trip you have to choose the route, interact with other road users, cross roads etc. Interaction promoting infrastructure together with measures increasing the attractiveness of pedestrian areas - those are possibilities of simplifying various tasks of pedestrians. Traffic planners should above all focus on children to ensure the walking trip is as simple and safe as possible.

1. Introduction

Walking is a fundamental element of our everyday mobility. It is the glue of the transport system. It connects the different traffic modes and keeps the traffic system together. Walking is considered a natural mode, which can be done without any technical instruments. It seems very simple compared to driving a car. Car drivers have to change gears, steer the wheel, use clutch, gas and brakes or handle the indicator in case of turning. Car industry spends millions of Euro on the development of new products. In-vehicle information systems (e.g. navigation systems, travel and traffic information services), advanced driver assistance systems (e.g. intelligent speed adaptation, adaptive cruise control etc.), traffic control systems (e.g. section control, car parking info, routing systems) are only some of the new technologies which simplify the task of driving. The car driver is probably the most explored road user in traffic. Pedestrians on the other hand play a minor role in traffic research and in traffic policy. The tasks of pedestrians are hardly ever discussed in scientific or political discourses. The only task pedestrians seem to have to perform is to put one foot after the other. Pedestrians, however, have to perform various tasks on different levels. This is mainly because the traffic system has become increasingly complex.

In this chapter an insight into pedestrian tasks will be given. First, psychological theories of task performances are presented; those describe mainly the decision processes of car drivers but are also relevant for pedestrians. Then, a short reflection on target groups and trip purposes together with the description of the trip process (pre- and on-trip) follows.

2. Theoretical models of task performance

When we try to describe how human beings perform a task it must be emphasized that they control their actions through different combinations of two control modes: the conscious and the automatic (Reason, 1997). The conscious mode is slow, sequential and logical, but limited in its capacity, being used only to pay attention to something. The automatic mode is subconscious, which means that the individual performs an automated task while being aware of its evolution but not of the process controlling the succession of singular actions. The process is very fast and allows to perform different actions in parallel, being virtually unlimited in capacity. Combining these two modes of control, Rasmussen (1996) describes three levels of performance that depend on the knowledge about the environment, the different interpretation of the available information and the experience with the task performance:

- A ***skill-based*** (SB) behaviour corresponds to the performance of routine and highly practised tasks in an automated mode with occasional conscious control on progress. As for pedestrians, the task “walking” is automated. You do not have to think to put one foot after the other. Also the speed is in most cases automated. Being tired slows down the walking, in a hurry the walk is automatically faster.
- The ***rule-based*** (RB) behaviour occurs when a need to modify the programmed behaviour has been identified. In this case there is a switch from the automated mode to a rule-based behaviour in order to follow memorised rules or procedures. Although walking is automated for pedestrians, the performance of the walking task imposes social interactions in the environment that are regulated either by traffic laws (e.g. one has to stop at red traffic light) or by informal regulations (e.g. in the case of social interaction with another pedestrian one draws aside from the right side). The pedestrian switches from the automated mode to a rule-based mode in order to follow the regulations. While following these memorised rules, the pedestrian applies some stored knowledge using a conscious thinking just to verify whether or not the solution is appropriate (e.g. when there is no car coming pedestrians cross by red light, illegally).

- ***Knowledge-based*** (KB) – this control mode occurs when the individual repeatedly failed to find some stored pre-existing solution while performing a task. Then, he/she has to use his/her knowledge and higher abilities to solve a problem, to understand a new situation and make the appropriate decision. In the context of walking, this level is used for example to plan a route or change the route planning, which is based on the geographic or spatial knowledge the pedestrian has of the environment.

These three levels of the task performance often coexist at the same time.

Rasmussen's model is a cognitive control of task performance. Michon (1985) differentiates tasks on a hierarchical level. Walking involves different subtasks performed at different levels of control. Michon talks about three levels:

- The ***strategic*** level (planning) which is a route planning according to defined goals, such as minimum time or avoidance of unattractive ways
- The ***tactical*** level (manoeuvring) involving manoeuvres related to social interactions in the environment: negotiations at intersections
- The ***operational*** level (control) includes of the operating of vehicle controls: change of direction when walking, stopping at hindrances, turning at corners, etc.

In the hierarchical model, the existence of a top-down control is assumed which means that decisions made at upper levels control behaviour at lower levels. However, this model allows for bottom-up control too, meaning that traffic conditions can lead to a change in tactical or strategic choices.

A baby has to learn how to walk. With training and practice, the actions performed at the operational level (putting one foot after the other, raise one feet higher in case of hindrances on the road etc.) become automated or skill-based. An automatic behaviour is consistent and insensitive to interference and occurs always in the same way, i.e. follows a pattern.

Decisions made at the tactical level are essentially based on memorised traffic laws that must be followed while walking or crossing roads or similar. These decisions are in most cases rule-based. At the strategic level, decisions, being mainly knowledge-based, are made on the basis of mental representations of the environment or some procedure knowledge. At this level, maps can provide some help particularly when walking in unfamiliar environments.

The model by Keskinen and Hatakka (Keskinen 1996, Hatakka 1998) is similar to the Michon model. In this task model a fourth level related to personal preconditions and ambitions in life was added. The following four levels can be differentiated:

- ***Goals for life and skills for living***: This level refers to personal motives. Lifestyle, social background, gender, age and other individual preconditions have an influence on attitudes, mode choice behaviour or the likelihood of being involved in an accident as e.g. pedestrian.
- ***Goals and context of the trip***: On this level the focus is on the goals why, where, when and with whom the walking trip is carried out (e.g. to make the trip during rush hours or not, do you take the children to the shop or shall they rather stay at home). It refers to Michon’s strategic level.
- ***Mastering traffic situation***s is a level which is similar to the “manoeuvring tasks” of Michon’s model. A pedestrian has to adjust his/her walking in accordance with the constant changes in traffic. He/she has to be able to identify hazards in traffic for example crossing the road while a car’s approaching at a high speed might produce the consequence that the pedestrian will accelerate his/her walking speed.
- ***Vehicle manoeuvring***: The bottom level can be compared with the operational level of Michon. It includes automatic, reactive tasks like passing other pedestrians without bumping into someone.

3. Task of pedestrians – parameters

Tasks can not only be subdivided into different theoretical levels of tasks performances but the kinds of tasks pedestrians have to perform depend on several parameters. In this chapter only two parameters are treated:

- o Who is performing the task? – **target groups**
- o What is the purpose of the walking trip? – **trip purpose**

3.1. Target Groups

Target groups are specified in detail in chapter 5 “Fictional abilities of humans and identification of specific groups”. In this chapter only two target groups, children and older people[1], are mentioned exemplary in order to point out the differences in task performance of various target groups.

<u>Children</u>

Performing the task of walking in road traffic is influenced by various physical and cognitive stages of development of the children (see Elliott 2003 or Daschütz 2006):

- o Three and four year olds are not able to differentiate whether a car is moving or standing still.
- o Only at the age of four children realise that an approaching car is getting bigger.
- o Children under ten may not be able to tell by noise from which direction a car is coming.
- o Approximately at the age of ten children are able to tell the speed and distance of an approaching car.
- o At twelve the field of vision is fully developed and children are able to employ their peripheral vision to see cars coming from various directions.
- o In average children under ten are smaller than cars. Being smaller than cars limits the ability to overview the road traffic sufficiently.

These are only a few limitations of children influencing children’s tasks performance. Such a task as for example crossing a road which an adult is able to perform on tactical or even operational level might require a strategic decision of children.

Children often hesitate when crossing the road on their own: where is the best place to cross, does the car driver see me, do I see the car driver, is the car far away enough etc.
In addition, the main difference to adults is that children move playfully. They hop and bounce along, jump, wheel objects, kick ball in front of them, pick up papers or other things from the ground etc. Children do a lot of things at the same time and the task of walking is secondary.

<u>Older People</u>

For older people walking may not be as natural as for young people[2]. The psycho-physical capabilities change with increasing age. The vision and hearing deteriorate, the kinetic

[1] Children and older people are the weakest group among pedestrians. If you plan for children and elderly all road users will profit. Besides, children and elderly are the group who walk the most. In Austria, 40% of all trips of children in the age of 6 to 15 are done on foot, 52% of all trips of people older than 66 are walking trips. In average, however, only 27 % of all trips in Austria are walking trips (see Herry et al. 2007).

[2] 1/3 of the population of the European Union are affected by reduced mobility due to individual impairments; this number includes many senior people as well as people who are temporarily disabled or convalescing (Risser & Haindl 2006)

moveability degrades, information can not be quickly absorbed, decisions and actions are delayed as a result. In addition older people get sooner tired than younger people (see Limbourg 1999).

All these psycho-physical changes influence the task performance of older people who walk. Simple tasks like lifting a foot can be difficult for the old ones. Climbing steps, walking fast e.g. when crossing roads may even become impossible at high age. Poor performance in such simple tasks, however, may lead to a subsequent decline in mobility. For that reason it is very important to provide appropriate infrastructure (e.g. low curb stones, sufficient places to rest) to assist people with restricted mobility and to adapt traffic to the needs of the weakest road users (e.g. green phases at signal crossing for pedestrians, which are adapted to the walking speed of slowly walking people).

3.2. Trip purpose

Not only the person, who is performing the walking but also the purpose of the walking trip affects the way how the task of walking is performed. Trips with certain purposes can be divided into trips to work, shopping trips, trips to the doctor, accompanying trips, education, visiting (friends and relatives), leisure and recreational trips.
A shopping walking trip includes carrying of bags and pushing trolleys at least on the way from the shop. This means that the person takes more space when walking on a sidewalk, is more considerate when passing other people and needs more time for the shopping trip as one might walk slower and would probably meet with numerous barriers on the sidewalk (e.g. parked cars on the pavement, crossings, high curb stones etc.).

When walking to the workplace you might be in hurry and want to walk fast. You need space to walk quickly without being slowed down by other pedestrians. You may decide for the less attractive (e.g. along a busy road) but rather faster route to work.

On trips when we take children to school, accompanying friends etc. it is necessary to take care not only of ourselves but also of the child or friend’s safety too. We might choose a longer but safer or more attractive route (detour through a park, crossing only at traffic lights or zebra crossings). This implies taking more time for the trip. When pushing a pram there will be more hindrances like stairs, narrow sidewalks and crowds of people etc. In subways the walkers may look for a lift.

Walking trips are often combined with the use of public transport. This intermodality affects the way how the combined trip is performed (e.g. is there a wheelchair access? are there low floor busses on this line?). It is very important that transport enterprises consider all their customers, not only public transport users but also pedestrians.

3.3. The task performance cube

In addition to these two parameters – target groups, trip purpose - the walking trip can be examined under two temporal aspects:

- Before the walking trip - Pre-trip tasks
- During the walking trip - On-trip tasks

If you consider the theoretical levels of the task performance models - the two parameters and the temporal aspect of a walking trip - you get a complex task performance cube, which underlines the variety of aspects which can be considered if you talk about tasks of pedestrians (see figure 1).

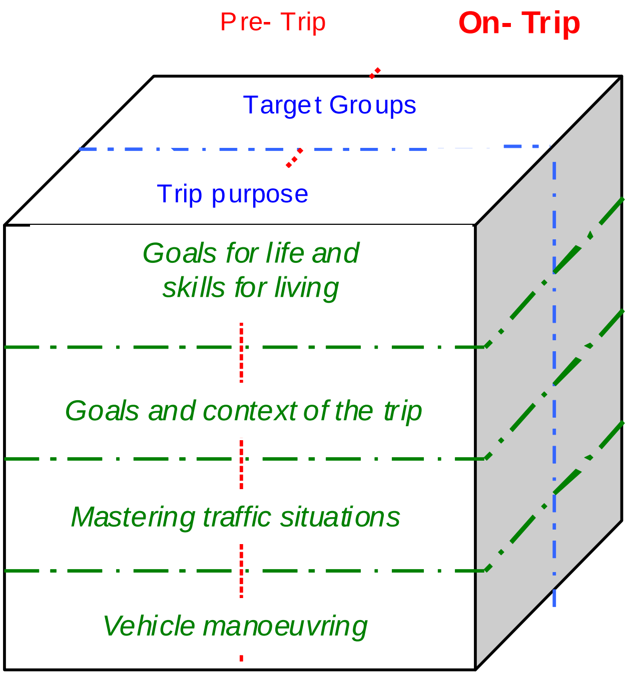

Figure 1 The task performance cube

3.4. Pedestrians' tasks before the walking trip – Pre-trip tasks

A walking trip starts at the point where you want to move from one spot to another one. Pre-trip tasks are performed mainly at the strategic level. They are goal and context based. One can differentiate between two kinds of trips:

- o Everyday (routine) trips
- o Non-routine trips

As for ***everyday trips*** there is no need to think too much about walking routes. The decision is made about the necessary equipment and the choice of mode. The equipment to take with and the transport mode choice is influenced by the trip purpose (e.g. you need a shopping bag for a shopping trip; you walk to work as this is the fastest transport mode), by weather conditions (e.g. you need an umbrella in case of rain, you might opt for walking when the day is sunny) and by your personal mental condition (e.g. you feel like making exercise and walk 20 minutes to work instead of taking the bus).

In case of ***non-routine trips*** the route must be planned ahead, certain information is needed: Where do I have to go? How far is the end destination? How long does it take? Is it possible to make the trip on foot? Is the place I want to go accessible at the time I would be there? Table 1 summarises some of the tasks a pedestrian has to perform before the actual walking trip starts.

Table 1 Tasks before a walking trip

INFLUENCING FACTORS	TASKS – STRATEGICAL DECISIONS
Trip purpose	✓ Equipment: What equipment do I need e.g. a heavy suitcase – is it really possible to make the trip on foot? ✓ Trip chains: Are there any other trips following
Accompanying people	✓ Needs of accompanying people: What do the people need, who'll accompany me (e.g. pram, scooter for children to be faster, walking stick for older people) ✓ Estimation of physical condition of the accompanying people: Can they really make the trip on foot?
Weather conditions	✓ **Equipment: Do I need an umbrella, rain boots, a warm jacket or only a cardigan etc.?** ✓ **Trip plan: Can I combine the walking trip with other means of transport in case of rain?**
Characteristic of the trip	✓ Choice of route: Which route to choose? ✓ **Duration of the trip: length of the trip, how much time do I have for the trip?** ✓ **Accessibility: Is the place I want to go, accessible for me; do I have to walk up a hill; over stairs; are there any ongoing road works?** ✓ **Intermodality: Do I have to combine the trip with public transport – (checking of time tables necessary)?**

Pedestrians can be supported by different kind of media to plan their walking route according to their needs: printed maps, internet – route planners, navigation systems, hot lines (see also chapter 4 "Parameters determining the choice of route for pedestrians in walk-able networks")

– *Printed Maps*
  Printed maps are useful for finding an appropriate route for walking purposes. Usual maps are city maps where all roads are listed and indicated or tourist maps where sightseeing's are listed. Maps, which consider the special needs for the various target groups of pedestrians, however, are not very common. Dead-end roads for car drivers for example do not mean a dead-end for pedestrians. Pedestrians will be able to proceed by walking through an apartment complex. Parents with a pram, people in wheelchairs might want to know if there are stairs or any other hindrances on their way to make the right decision for the shortest and most convenient way.
  The city of London offers a special London Pedestrian Route Map (see http://www.spacesyntax.com/main-nav/projects-and-clients/london-pedestrian-routemap.aspx).The map is based on extensive research of walking patterns in London. Two aspects were relevant for the research work: first, an understanding of where people walk and second, an understanding of why people choose to walk where they do. The map provides a simple, memorable picture of the major walking routes in the capital. The route map shows how key places are connected by straightforward routes of varying character. The aim of the London Pedestrian Route Map is to promote walking in the city.

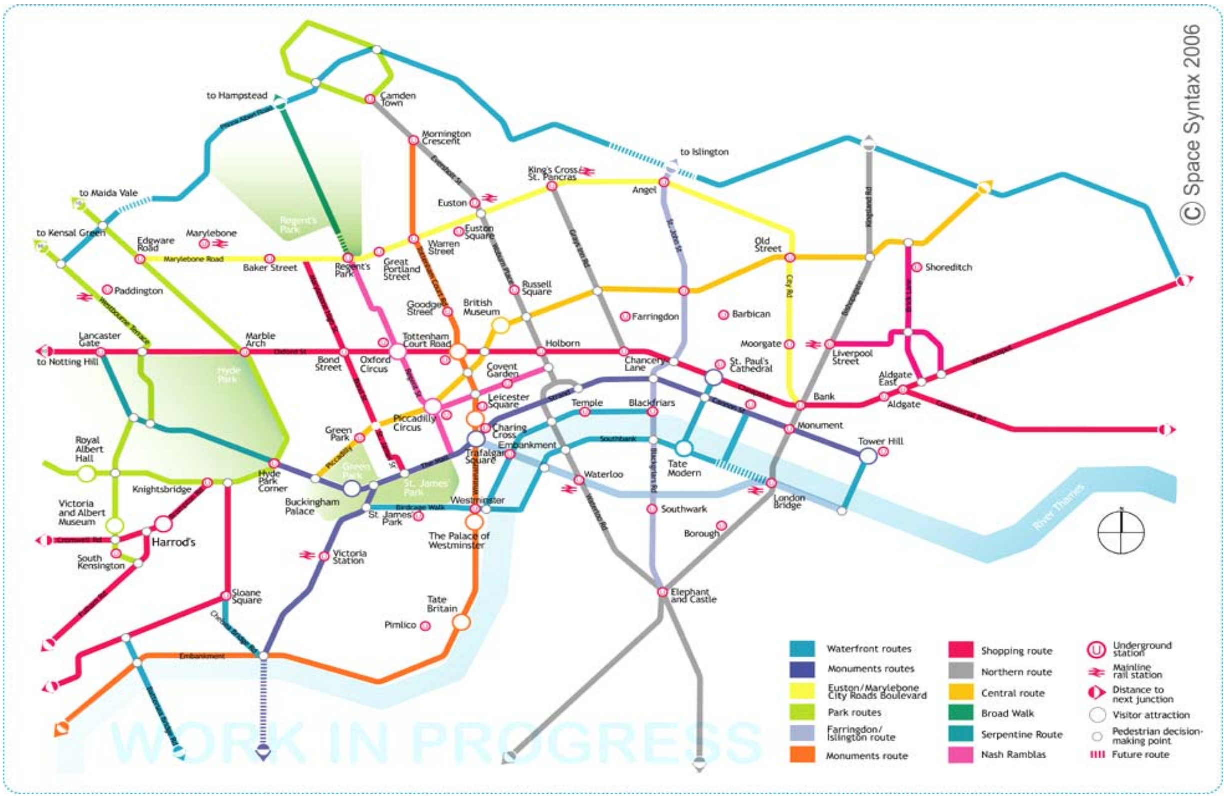

Figure 2 London Pedestrian Route Map

Source: http://www.spacesyntax.com/en/projects-and-clients /urban-projects/london-pedestrian-routemap.aspx

One problem with maps is that quite a lot of people are not able to read maps. In a Dutch study only 10% of the interviewed people were able to locate their place on a detailed city map. This means if you provide special maps e.g. for pedestrians, it is very important to design a map in such a way that it is also understandable for children.

– *Internet – Route planners*
  Planning a walking route by internet is getting more common in recent years. Route planners where you just put the address of the starting point and the end point are available for many places around the world. In some cases you even can plan if you are going by car, by bike, by public transport or on foot. The special needs of pedestrians, however, are hardly ever considered. Dead-end roads are defined according to car drivers' needs; roads with stairs are not marked. But in the internet one might even detect that there is a building site blocking the road. This might be valuable information for blind pedestrians. Maps, route planners have to be clear and understandable.

– *Navigation-systems*
  Navigation systems are getting progressively popular. The main advantage to maps is that visual instructions are supported by verbal (audio) explanations. The problem is that people just follow a voice without orientating themselves at certain spots on the way to their destinations, so that usually they need their "Tom-Tom" (portable GPS device) on their way back, too. This means that the process of internalisation of a walking route will take much longer.

– *Hotlines*
  Hotlines for public transports are common. You can ask for the next and the best train connections on the phone, you can complain about delays etc. London introduced a hotline for pedestrians but in general hotlines for pedestrians are not commonplace. In the age of mobile phones it might be an attractive alternative to call a hotline and ask for the shortest way. Besides, one can voice disappointments about e.g. building sites which are not appropriately secured for pedestrians or about badly maintained sidewalks.

3.5. Pedestrians' tasks during walking trip – On-trip tasks

Tasks that pedestrians have to perform during the actual walking trip are of tactical pro-active or automatic-operational character. Tasks on this level can be subdivided into:

- o tasks, when choosing a route
- o tasks, when walking on sidewalks and designated areas for pedestrians
- o tasks, when crossing roads

Table 2 exemplifies some of the pedestrians' tasks during the trip.

Table 2 Tasks on the walking trip

MAIN TASKS	SUBTASKS
Choosing the route	✓ Looking for sign posts, info-points, landmarks etc. ✓ Reading of street names ✓ Asking people for the right way ✓ Checking if you are still on the right road or best route ✓ Checking on the time
Walking on sidewalks	✓ Taking care of barriers on the way e.g. dog's excrements, dustbins, traffic signs, high kerbstones, stairs etc. ✓ Checking up the condition of the sidewalk e.g. is it uneven, slippery, wet ✓ Interaction with other road users, when passing or being overtaken e.g. other pedestrians, cyclists, car drivers, who are coming out of garage, ✓ Keeping traffic rules e.g. stopping at red traffic light, using the sidewalk and not the road except for crossing reasons
Crossing of roads	✓ Functionality of the location: Choice of the best place to cross: What is the shortest way? What is the safest way? Are there many walkers who want to cross? ✓ Checking up the crossing conditions: *situation estimation* of danger e.g. estimating the speed of approaching cars; *visibility* e.g. do walkers notice the oncoming traffic? do car drivers notice the walkers?; *infrastructural conditions* e.g. do walkers have to press a button to activate the pedestrian traffic light, ✓ Interaction with other road users when crossing e.g. eye contact, hand signal ✓ Keeping traffic rules e.g. crossing when it is green, using zebra crossing in 50m surroundings,

Many of these tasks are automated. All problems for pedestrians which are connected to safety, accessibility, comfort, attractiveness, intermodality disturb the smoothness of walking. In the EC Project PROMPT "*New means to **prom**ote **p**edestrian **t**raffic in cities*" the main problems of pedestrians in different fields were summarised (see table 3, Rauhala, http://prompt.vtt.fi compare chapter 3A "Factors and mechanisms determining strategic decisions with regard to walking").

Table 3 Problems for pedestrians in various fields

Field	*General Problems* & Problems with respect to task performance
Safety	✓ *High speed of cars*: estimation of speed, detecting the car in time, ✓ *Mixed cycle lanes and walking paths*: you have to watch out for cyclists, detect the cyclist in time ✓ *Short crossing times – long waiting times*: hurry up when crossing, stress, impatience ✓ *Slippery pavements, unevenness of pavements, rubbish on the pavements, gaps in the pavement*: detect unexpected hindrances in time, adapt the walking speed to the walking conditions, danger for the elderly to fall ✓ *Parked car, block crossings:* disturb the visibility of pedestrians & vice versa, problems for pedestrians to detect cars in time
Accessibility	✓ *Streets with high motor traffic volume*: find gaps to cross the road ✓ *Walking paths including steep hills or slopes*: need of help in case of a handicap ✓ *The pedestrian network:* find the right and shortest way ✓ *Poor crossing facilities like wide streets, long waiting times, short sight distances etc.*: cross the road before a car is coming, insecure situation mainly for children ✓ *Narrow or missing sidewalks:* side step for other pedestrians, you have to watch out for overtaking cars ✓ *Parked cars on pavements:* bad visibility, need of detours
Comfort	✓ *Lack of places to rest, lack of convivial places*: no place for recreation when pedestrians are tired, ways seem longer because of unattractiveness ✓ *Bad air quality, bad smells (gas emissions or other disturbing smells)*; *high noise level:* distraction, bad for the health ✓ *Socially insecure places*: fear, avoidance of certain places ✓ *Lack of public toilets:* reason for staying at home; restriction of mobility ✓ *Lack of protections against weathering:* becoming wet, dirty ✓ *Badly illuminated sidewalks:* fear, danger of falling; detect hindrances in time ✓ *Lack of signs, information points, guiding systems for visually impaired people:* to find the right way, to move safely
Attractiveness	✓ *Insufficient pedestrian network, unattractive built environment, lack of green areas, monotony of pedestrian areas:* physical and visual fatigue ✓ *Lack of services, facilities and commercial activities; lack of urban furniture and equipment (seating, public toilets, etc.):* feeling of inconvenience ✓ *Lacking sufficient illumination:* fear, danger of ignoring of hindrances
Intermodality	✓ *Poor offer of public transport (long intervals, too long distances between stops):* long trips, no bus in walking distance ✓ *Badly designed crossings at public transport stops:* dangerous crossing situation, need of detours, ✓ *Hindrances at the public transport stops (stairs, scary subways etc.)*: barriers for disabled people – restriction of mobility, need of detours ✓ *Insufficient equipment at stops (no weather protection, no time tables)*: wet cloth, impatience, uncertainty ✓ *Filthy public transport stops:* fear to get dirty, feeling of inconvenience

3.6. Choosing one's route – discussion of examples

Persons who are not familiar with an area have to look for clues themselves: Is this the right way? Are there any info points? Is this the fastest way? Often pedestrians are steered towards their target by sign posts put up for car drivers. Tourist cities and villages usually offer guidance systems to the most famous sightseeing of their town. The needs of pedestrians and of their various target groups are hardly considered. This sometimes results in some badly designed sign posts as the following picture illustrates:

There are positive examples of ***pedestrian guidance systems***. In Bad Vöslau, a city in the eastern part of Austria (approx. 7000 inhabitants), a special guidance system is provided for pedestrians (see Schwab, Ruland & Strasser 2008). The aim is to motivate people to walk more frequently by showing them the shortest way to their final destination. The walking time to the various destinations is always indicated on every sign post. The guidance system is based on the walking patterns of the people in Bad Vöslau. It was integrated in existing information points and city maps.

Unfortunately the guidance system does not consider the needs of people handicapped in their mobility. Mobility barriers like stairs are not indicated. Blind or visually impaired people need audio and not visual guidance. This could be easily provided in the age of telematic systems.

In addition to pedestrian guidance systems the existing traffic signs must be adapted to the needs of pedestrians. The traffic sign “dead-end road” signals that the road does not continue. The information is meant for car drivers but not for pedestrians and cyclists. The Swiss pedestrian lobby “Fussverkehr Schweiz” started a pilot project in 2006 and added pictograms to the existing “dead-end road traffic signs” which indicated the dead-end for the various road users (Thomas, Dischl 2006). The results have shown that the road users had no problem to understand the new information on the traffic sign and very much appreciated the additional information. Putting pictograms on existing traffic signs is a cost efficient method but can be very effective to avoid detours for pedestrians.

Another example for using car traffic signs for pedestrian purposes is “route deviation signs”. Car drivers are always redirected in case of road works. Pedestrians are often confronted with given facts: “Connecting passage closed!” Pedestrians are sensitive for detours. They want to be informed on time of “closed connections” to avoid going a long way round.

3.7. Walking on sidewalks and designated areas for pedestrians – needs of pedestrians

Walking is more than simple locomotion. Walking can be hasting, marching, strolling, sauntering, dawdling or ambling. Fast walking people need more dynamic areas while slowly walking people are sometimes incalculable in their movements; they change directions, walk from one side to the other or stop suddenly. Some walkers carry shopping bags or briefcases, others push prams or walk on the stick. There is a huge variety of pedestrians who move on the same place. In order to be able to carry out the task of walking smoothly for various target groups it is necessary to provide a ***connecting pedestrian network.*** The present urban development still promotes the motorised traffic. In many cases pedestrians are offered residual areas.

Demands on a pedestrian network

According to “Fussverkehr Schweiz” a pedestrian network has to be (see Fussverkehr Schweiz, 2007) ***safe, direct penetrable/cross-linked, well arranged, attractive and usable***.

Other scientists talk in this context about the 5 C’s: connected, convenient, convivial, conspicuous and comfortable (compare chapter “A qualitative approach to assessing the pedestrian environment”). Similar parameters for a high quality pedestrian network were also defined in the EC-Project HOTEL and ASI, in which good walking conditions were connected to a high life quality (Bein et al. 2004, Kaufmann et al. 2005).

- safe

Safety is one of the most important aspects when talking about pedestrian network. Due to a decrease of the pedestrian share in the modal split the risk of getting injured as a pedestrian increased in the last years in Austria despite reduced accident rates (see Frey 2008). Safe, however, does not only refer to the objective safety of pedestrians (e.g. the risk of getting injured) but to the subjective safety, too. How safe do pedestrian feel themselves while walking or crossing a street? Furthermore you can also distinguish between objective and subjective security. In this respect the term security refers to criminal incidents. The feeling of insecurity in subways for example might be the cause for dangerous crossings on the surface.

A safe pedestrian network includes minimising *conflicts between other road users.* Mixed cycle and pedestrian paths for example should be avoided as several studies pointed out because they increase the potential for conflicts between cyclists and pedestrians (see Wunsch, Haindl & Ausserer, 2007). Speed of the motorised traffic has to be adapted to the pedestrians' needs. The smaller the difference in speed between the various road users the better will pedestrians enjoy walking. 30 km/zones are one possible solution.

As for subjective safety places of distress should be avoided by appropriate network planning and sidewalks well illuminated at night time.

- direct/penetrable/cross-linked

As noted earlier pedestrians are sensitive towards detours. Networks should consider the shortest and most direct way. You often see this in parks where new paths are designed across a lawn in order to make a short cut. Pedestrians need a compact and close-meshed path network. Waiting time should be minimised. In addition, pedestrian network has to be cross-linked to the public means of transport. Easy accessible underground stations, short transfer distances or protections shelters for weathering at bus stops are only a few examples of measures for pedestrians' benefit.

- well arranged

A well arranged network includes being able to review the traffic situation to understand the concept of the network and to be guided by pedestrian guidance systems. Consistent design elements for walking areas e.g. an even pavement enable pedestrians to perform their task of walking smoothly and without conflicts.

- attractive/useable

Walking in attractive environment is much more enjoyable than in an unattractive environment. Pedestrian networks should be multifaceted and diversified with a high sojourn quality. Places to rest, protection against weathering are important aspects contributing to the attractiveness of pedestrian network (see www.size-project.at or Wunsch, Haindl & Ausserer, 2007). There is a demand for guidelines for designing green areas and providing places to rest.

Even though pedestrians are able to move in jammed spaces they need places to enjoy walking. It is necessary to meet the needs of both fast and slow walkers. The "Masterplan Verkehr" (which is a traffic concept) for the city of Vienna requires that sidewalks are minimally 2 metres broad (see Oblak, 2003). Fussverkehr Schweiz demands even a minimum width of 2,5 metres for sidewalks (see Regli, 2008).

Moreover, areas for pedestrians have to be well maintained and cleaned regularly. In an Austrian study for example, dogs' excrements on pavements were mentioned as one of the biggest annoyances for pedestrians (see Risser, 2002).

Useable concludes that the needs of various target groups have to be considered. A pedestrian network should be accessible also for people with restricted mobility.

3.8. Crossing Roads – examples how to simplify the task of crossing

Crossing the road is probably the most complex task for pedestrians and sometimes a very dangerous activity, too. In Austria in 2007 one quarter of all pedestrian accidents happened at junctions with zebra crossing.
Crossing is a task where usually social interactions take place. Children are told to look left and right, to cross the road only when the traffic light shows green. These tasks might get automated when crossing the road. One aspect which is sometimes forgotten to teach children is to get in social interaction with car drivers, cyclists and alike when crossing a road (the importance of eye contact etc.).
There are several infrastructural measures which can be implemented to "simplify" the task of crossing for pedestrians. An Austrian study (see Haindl & Risser, 2007) suggests following measures for the increase of traffic safety and sojourn quality for pedestrians:

– *Red framed zebra crossings*
  Around schools in Vienna zebra-crossings were framed red to attract the attention of car drivers.

Figure 3

– *Enlargement of sidewalks at crossings*
  In Vienna this infrastructural measure is called "Ohrwaschln". It was antagonised by the car lobbies as parking spaces got lost. This measure increases the safety of pedestrians and makes walking more comfortable.

Figure 4

– *Red framed zebra crossings Drawing through of sidewalks –*
  At crossings sidewalks are on the same level as the roadway. It makes walking more comfortable and safe as car drivers are more likely to decelerate before the crossing.

Figure 5

– *Lifting of the whole crossing*
  The crossing is lifted so that all road users are on the same level at the crossing. Again, a measure which increases comfort and the safety of pedestrians.

Figure 6

– *Traffic islands*
  Traffic islands serve as an aid for crossings. At the same time they narrow the road so that passing cars must reduce their speed.

Figure 7

Sometimes a lack of space does not allow building a traffic island. In a Swiss pilot study *marked traffic islands* in the middle of zebra crossings were tested (see Schweizer et al., 2008). Results have shown that "marked traffic islands" have the same effect as built traffic islands. Pedestrians feel safer and more often cross without hesitating because more car drivers stop and give way to pedestrians (71% before and 89% after). In Austria at ordinary zebra crossings only 46% of the car drivers give way to pedestrians (see Kolator, 2008)

<u>Traffic lights</u>

Traffic lights are popular measures to simplify the task of crossing for pedestrians. Traffic lights, however, do cause above all comfort problems for pedestrians. Usually they are dimensioned to fit the car capacity. Green phases for pedestrians are considered the very end of the "traffic light dimension process". The results of several studies have shown that pedestrians see too short crossing times and too long waiting times for pedestrians as a big problem for the attractiveness of walking (see Wunsch, Haindl & Ausserer, 2007). Short green phases induce the feeling of stress not only for the elderly. Pedestrians need time to cross a road. They do not want to run just to be able to cross within the given time period. If pedestrians have to wait too long for the green phase they get impatient. This increases the risk of crossing the road when the traffic light is still on red. "Count-down pedestrian traffic lights" - traffic lights that indicate how long you have to wait till the light changes to green - are one feasible measure how to reduce the subjective waiting time (see Fischer, Risser & Ausserer 2004).

In the community of Thüringen in Vorarlberg a new traffic light regulation was tested for pedestrians. Pedestrian only have a zebra crossing and no traffic light regulation (see Schwab, Ruland & Strasser, 2008). Car drivers have a traffic light (only yellow and red), which is usually switched off. Children, the elderly or those who are scared to cross the road are able to stop the cars by pressing a key which turns on the traffic light for the cars within 15 seconds. So far the test was successful as it reduced waiting times for pedestrians and the number of "red-light crossings" considerably.

The tasks for pedestrians can also be simplified by other infrastructural measures. In Switzerland or France but also in other European countries in some areas special zones like shared space or encounter zones were established. Pedestrians have priority in these areas and the communication between road users has improved (for more information to shared space and encounter zones see e.g. http://www.hs-owl.de/fb3/fileadmin/stephan_rainer/Shared_Space/SVT_61-65.pdf). or http://www.begegnungszonen.ch/home/index.aspx)

3.9. Design principles for facilitation of the task of road crossing for children

<u>*Speed*</u>

The objective is that children of preschool age should not meet with cars in their play areas or on the routes the use; in some cases, though, vehicles travelling at a maximum of walking pace (or crawling speed) can be accepted. Children from the age 7 to 12 may not cross streets at locations where vehicles speed exceeds 15-20 km/h. As for the older children the same principles apply as for other unprotected road users: they should not cross at locations where vehicles speed exceeds 30 km/h. This applies to routes to school, to leisure and for free time & social activities.

Teichgräber (1983), Ashton (1982), and Waltz et al (1983) show that the risk of fatal injury is less than 10% if vehicle speed is 30 km/h or less; it is 50% if vehicle speed is around 50 km/h, and at least 90% if the speed is 70 km/h or higher. Also, Nilsson (2000) showed that a change in speed has the greatest effect on the worst accidents. The number of accidents involving personal injury is proportional to the square of the change of speed, while the number of fatal accidents is proportional to the fourth power of the change of speed.

When heavy vehicles are involved, the degree of seriousness of accidents is independent of vehicle speed (Leden, Gårder and Pulkkinen, 2000). However, the chance of accidents varies with speed. Therefore, it is even more important that safety measures are implemented if collisions with heavy vehicles are to be avoided.

Seeing and being seen: orient ability and simplicity

Figure 8 A 5th grade pupil thinks it is dangerous to use the pedestrian crossing at the intersection because "You feel all dizzy" (Leden, 1989).

To see and be seen is important for all road users if a high degree of safety is to be achieved. Obstacles to visibility are therefore negative factors in child safety, see e.g. Räsänen and Summala (1998). Children are killed more often than other age groups at places with vision obstacles (Johansson, 2004). When children were killed at crossings, there were obstacles to visibility in 36% of cases, and on stretches of road in 60% of cases. Some suggestions for improved visibility are given below:

On streets where parking is permitted, it is suggested that there is always an extended pavement at pedestrian crossings to narrow the road and to increase visibility between parked cars. However, the safety effect may not be obvious. Elvik and Vaa (2004) estimate that pavement extension reduces the number of accidents by 5% (confidence interval: -58; +117). Since children are more likely than others to step out between parked cars (Johansson, 2004, Demetre and Gaffin, 1994), it is clear that such measures are more important for them than for other age groups, since small children can be entirely hidden behind cars.

The street should have only one lane in each direction, since more than one lane creates problems especially for children. At signalized multi-lane streets, the stop lines should be pulled back to increase the view and visibility for and of children. It is clear that this type of measure is more effective for children than for other age groups since children are more often involved in accidents at places with more than one lane in the vehicle direction. Children were more often involved in crashes with overtaking cars than other age groups (Johansson, 2004).

There should be always a traffic island in the middle of a road at pedestrian and cycle crossings. Elvik and Vaa (2004) estimated that traffic islands decrease the number of accidents by 18% (confidence interval: -30; - 3). Traffic islands are very effective by simplifying the crossing task as there is only one vehicle direction to be taken into account, and the distance to the safe area (the island) is shorter.

Mixed phases at signal-controlled crosswalks should be avoided. The number of personal injury accidents increased by 8%.

Figure 9 The risk of collision between cycling school children and motor vehicles was high at intersections controlled by traffic signals with a mixed phase (Leden, 1989).

When crossings are signal-controlled there should be separate phases for pedestrians and right or left turning traffic. Is this not possible, the pedestrian phase should start several seconds earlier than the vehicle phase.

To improve orientation, the suggestion is that footpaths and cycle paths be moved to sections of road between intersections so as to reduce the number of directions vehicles can come from, assuming that vehicle speeds are low. Leden (1989) observed that the interaction between children and drivers improves if the crossing point is on a section of road where vehicle speeds are low.

Design principles for traffic customisation for children can be illustrated in the following hierarchical systems where Requirement No. 1 is the most important (Johansson, Gårder and Leden, 2004):

1. The objective is that children of preschool age may not encounter cars in their play areas or in places they walk. In exceptional cases, vehicles travelling at a maximum speed of walking pace can be interacted with. Children from 7-12 years should not cross at locations where vehicle speeds exceed 15-20 km/h. For older children, the same principles apply as for adult unprotected road users: they should not cross at locations where motor vehicle speeds exceed 30 km/h. This applies to routes to school, to social and other leisure activities. However, other measures than low speeds are necessary in order to generate a systematic traffic planning for children.
2. Approaches should have only one entry lane; this must be systematically implemented in areas where children cross streets, at bus stops, at schools and in residential areas.
3. For traffic volume and structure, the aim is that traffic flows should be light, with few or no lorries/trucks or buses.
4. Layouts and sections should have good visibility and clarity. There should always be traffic islands in the middle of the road at pedestrian and cycle crossings, both at formal crosswalks and at other locations where pedestrians frequently cross.

4. Conclusions

Pedestrians are an inhomogeneous group of people, who perform various tasks on different levels. Being aware of the tasks pedestrians have to perform makes it easier to design pedestrian-friendly infrastructure, to provide helpful pedestrian maps and navigation systems which consider the needs of various target groups. Walking should never be treated as an isolated mode of locomotion. It connects different transport modes. It is the key of intermodality. For that reason it is very important to bear the needs and tasks of pedestrians in mind when making any traffic planning decision.

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Factors and mechanisms which determine the outcome of strategic decisions with regard to walking.

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Summary

Pedestrians constitute a major group of road users. In this paper an attempt is made to sketch a general picture of the pedestrian's needs, which should be valid for the majority of countries. The focus is laid on the pedestrians' safety and accessibility, particularly to the needs of pedestrians with disabilities. The needs of pedestrians, as far as infrastructure and policy measures are concerned, are usually examined in the framework of short term traffic management studies or town planning studies. The experience so far shows that little attention is paid to the pedestrians, due to various reasons.

The basic aim of this chapter is to present the physical health and competences factors which determine the outcome of strategic decisions with regard to walking. Additionally, pedestrians' needs/problems and infrastructure characteristics for pedestrians and pedestrians with disabilities as well, will be presented.

Most of the cities face severe traffic and related environmental problems, especially in their central areas. The lack of an integrated pedestrian street network and the relatively poor geometric characteristics of the pavements, among other reasons often lead to an unacceptable level of service for the movement of pedestrians. Special emphasis is usually given to the safety and accessibility issues related to the movement of pedestrians.

In addition, the results of various questionnaire based surveys, aimed at the identification of the needs of the pedestrians are presented in this chapter.

1. Introduction

Walking is one of the most important ways of travelling. The quality of the walking environment often does not meet the pedestrian's quality needs. Pedestrians are eligible to use public space (road infrastructure, sidewalks, footpaths, access in private areas) in a safe and comfortable manner.

Working Group 1 focuses on physical needs of pedestrians, visible and objective behaviour and the "technical" ergonomics of the physical and social environment and the transport modalities. The basic functional needs of pedestrians include the following: need for mobility, need for safe mobility, convivial mobility and challenging sojourn. Improvements for pedestrians' mobility include: sidewalks, pathways, intersection crossing improvements, mixed use development, etc.

This paper attempts to examine the "objective" factors and mechanisms which determine the pedestrians' travel and/or sojourn motives. Especially, an attempt is made to examine physical health and competences factors and mechanisms which determine the outcome of strategic decisions with regard to walking.

3.1 Objectives factors and mechanisms which determine the pedestrians travel and/or sojourn decisions-groups which can be distinguished

3.1.1 Health and competences factors

3.1.1.1 Physical ability

The pedestrians' physical ability is affected by a great range of factors. A significant number of these factors can change even during a walking journey. Table 1 presents the pedestrians' physical abilities.

One of the main groups which can be distinguished by the purposes of this research refers to the ***vulnerable road users***. At this point it should be referred who are the vulnerable road users. "Vulnerable road users" is a term commonly used to describe those people who are likely to suffer when in conflict with cars, buses and other large vehicles. It may also be used to describe users of the highway whose mobility is in some way reduced or who face barriers to movement in the highway environment. These road users include:

- Pedestrians.
- Elderly people.
- Children.
- People with small children.
- People with physical, sensory and mental problems.
- People with temporary accident injuries or whose mobility is impaired through pregnancy.
- People carrying heavy shopping or luggage.

It can be said that trips by car is the safest way of travel for the elderly while walking and cycling impose more danger. The elderly have probability of 9-times and 8-times respectively, to die as a pedestrian rather than as a car driver/passenger. These high levels of risk are accentuated when exposure measures are taken into account. Thus, few older people tend to travel less, and may limit their trips nearby, familiar areas only. Furthermore, the ageing of society means that in the future there will be a larger number of older people in the community; this requires the improvements of their mobility. "*Given the 'greying' of society, there is an urgent need to change policies and strategies to, first, recognise the problems, and secondly, to develop appropriate facilities and programs to support continued mobility, safety and well-being of the oldest members of our communities*" (Jennifer Oxley et al, 2003).

As for children and youngsters, it appears that they are a 100 times more likely to be killed as road users than by other road users (Sustrans, 2001). The results from a survey indicate that young people who grow up in areas with low traffic volumes, “see” or experience a nicer, more pleasant, and more friendly local environment than those who live near areas with heavy traffic. The characteristics of such areas may have negative consequences to the children future health and behaviour (Greenwood, D.,et al, 1996; Campbell, C.,et al, 1999).

Table 1 Pedestrians’ physical abilities

Ways in which pedestrians differ	Affecting	Impacting upon
Height	Ability to see over objects Ability to be seen by others	Sight lines
Speed of reflexes	Inability to quickly avoid dangerous situations	Crossing opportunities
Stamina	Journey distance between rests	Resting places
Visual perception	Ability to scan the environment and tolerate glare	Legibility of signs Detection of kerbs and crossing locations Trip hazards Tactile paving Judging traffic
Attention span, and cognitive abilities	Time required to make decisions Difficulties in unfamiliar environments Inability to read or comprehend warning signs	Positive directions 'Legibility' of streetscape Consistency of provision Use of symbols
Tolerance for adverse temperature and environments	Preference for sheltered conditions	Location and exposure of routes
Balance and stability	Potential for overbalancing	Provision of steps and ramps Kerb height Gradients Crossfall
Fear for personal safety and security	Willingness to use all or part of a route	Lighting Surveillance Lateral separation from traffic Pedestrian densities Traffic speed and density
Manual dexterity and coordination	Ability to operate complex mechanisms	Pedestrian activated traffic signals
Accuracy in judging speed and distance	Inopportune crossing movements	Provision of crossing facilities
Difficulty localising the direction of sounds	Audible clues to traffic being missed	Need to reinforce with visual information
Energy expended in movement	Walking speed	Crossing times Length of journey Surface quality

Source: (Axelson et al, 1999, State of Florida Department of Transportation, ITE Traffic Engineering Council Committee, 1998, Organisation for Economic Cooperation and Development, 2001, Austroads, 1995, Roads and Traffic Authority New South Wales, 2004).

A survey carried out in France showed that the majority of accidents involve children between six to eight years old. It was noticed that boys are more frequently involved in road accidents (60%) than girls (40%) (Cambon et al, 1989). According to the results from an American survey, seven in ten Americans (71%) stated that they walked or rode a bike to school when they were a child. But, today the majority of children (7 to 17 years old) go to school accompanied by their parents (53%) or by bus (38%). Less than two in ten (17%)

walk. Parents stated that the main reason that children do not walk or bike is the schools' great distance (66%). Other reasons, according to Belden Russonello and Stewart Research, were: too much traffic and unsafe route (17%), fear of abduction (16%), crime in the neighbourhood (6%), lack of convenience (15%), and children not wanting to walk (6%). Another walkability survey (Kelly J. Clifton) implemented in College Park during the months of May-June in 2003. Residents of College Park stated that they walking for health reasons (51%). However, many also reported that they walk because it is convenient (47%) and/or that walking was their primary mode of transportation (37%). Most respondents stated that they usually walk alone (63%) and with friends or family (35%). Thus, "*the community seems to be strongly motivated to walk for health reasons*".

3.1.1.2 Mental Health benefits of daily walking

Abstract
A growing amount of literature deals with health topics related to the physical environmental elements as well as the physical activity, particularly walking and cycling. Minor attention has been paid to the quality of urban space related to social and mental well-being. We have selected a review of recent literature (years 2000 to 2008) relating physical activity (PA) and mental health (MH) with the Built environment. Evidence suggests that even moderate and low levels of physical activity (like normal walking) are beneficial, preventing clinical and sub clinical medical care; even mental health benefits from low level physical activities. This paper uses a bibliographical approach to document the current state of the art of the relationship between Mental Health and the built environment.

Introduction
Urban form and transportation systems influence public health in a variety of ways; providing environmental quality, trough a variety of designs and forms of land use and transportation solutions. Decisions affecting neighbourhood characteristics, pedestrian oriented design, calming zones, transport policies, etc., have the potential to promote social inclusion, social capital and play a major role in keeping the population physically active.

There is a long tradition promoting physical activity to obtain physical benefits and we can find evidence of this relationship along the scientific literature. Also mental health benefits have been, plausibly associated to physical activity but this relationship has been not clearly uncovered. Recent literature sets a growing interest in research suggesting that physical activity has the potential to contribute to improve well-being, self esteem and to reduce symptoms of mental health disorders.

The term mental health is used to describe either a level of cognitive or emotional well-being. Though the most of us don't suffer from a diagnosable mental disorder, it is clear that some are mentally healthier than others. The World Health Organization (1948) defines mental health as *"Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity"*
Mental health as objective fosters the needed qualities of pedestrian even further; a recent Resolution of the European Parliament (Tzampazi, 2009) has come to declare that mental health and well-being are key factors in the EU's Lisbon Strategy objectives whereas they are central concepts to the quality of life of individuals and society and convey heavy personal, social and economic consequences.

In this paper we present documented evidence on the relationship, even causal relationship, between Physical Activity (PA) and Mental Health (MH). Through focus on some components of PA and MH more specific relationships can be uncovered, in particular those related to activities like walking and strolling. Then, we will explore a few experiences with pedestrian oriented designs or neighbourhood characteristics and its mental health outcomes.

Methodology

Under the basis described above we proceed to do the following steps:

1. Search for reviews in the topic area: Built Environment, Physical Activity, Health, relating them and select them with a inclusion criteria.
2. Analyse the literature selected in order to find out which are the mental health benefits that can be reasonably derived from low intensity levels of exercise like walking.
3. Contextualize the benefits to be plausibly achievable by activities like walking in a pedestrian friendly environment from the literature reviewed.

Specific objectives:

Search for reviews and articles: terms and databases

The potential scope terminology is extremely wide but for the purposes of this research just a few of them were of interest. The table 1 below lays out the terms used for each topic.

Table 2 Terms corresponding to the different topics used in the search

BUILT FORM/ URBAN DESIGN	PHYSICAL ACTIVITY	HEALTH	
		PHYSICAL	MENTAL
Land use Neighborhood characteristics Pedestrian oriented Calming zones Transport policies	Exercise Active living Walking Strolling	Diabetis Coronary Obesity	Wellbeing Self-esteem Perception of self-efficacy Depression Anxiety Cognitive fucntioning

The search strategy involved the following sources of information:

- Medline, SCIRUS, Centres for Disease Control and Prevention, Google Scholar and literature at hand.
- Limited to “Systematic review” and “review” articles
- Limited to English language
- Limited to years after 2000Criteria for inclusion or exclusion of the findings
- Inclusion criteria: Review article; Specific and sufficient interest in low intensity of physical activity and mental health even from a clinician point of view and friendly pedestrian environments practices
- Exclusion: Not specifically relevant to physical activity or mental health problems; Not related to walk and pedestrian ambience in urban environment. Duplicated items. Individual studies.

Summarizing the findings

The selected findings were summarized according to:

a) Health benefits of physical exercise.
b) Physical exercise association with mental health outcomes; intensities, frequencies, distances, to be significant
c) And pedestrian friendly environments and health outcomes associated.

Results

Health benefits of physical exercise

There is a large body of literature on this topic and on the other hand the evidence is relatively well consolidated. Consequently a selection of two reviews was considered to be sufficient.

- According to the U.K. Department of Health (2004) Physical activity is effectively associated to health. The efficacy of the suggested levels of physical activity: is obtained in bouts of moderate intensity of 20-60 minutes but short bouts (10-15) have also induced a significant health changes according to experimental works. Aerobic forms of exercises are the most consistent in its results (walking, jogging). The recommendation is to walk “briskly” 30 minutes per day, five days per week.
- Penedo and Dahn (2005) review studies involving randomized clinical trials in which physical activity was associated with better quality of life and health outcomes. No causal interpretation is suggested in their analysis because the sample sizes of these trials are limited.

Physical exercise association with mental health outcomes; intensities, frequencies, distances, to be significant

On this issue six reviews were found:

- Stathopoulou, Powers, Berry, Smits, and Otto (2001, Febr) review the application of exercise interventions to clinical populations diagnosed with depression, anxiety, and eating disorders with evidence of substantial benefit. The meta-analysis on 11 treatment outcome studies of individuals with depression yielded a very large combined positive effect for exercise relative to control conditions. Based on these findings, the authors encourage practitioners to consider additional exercise interventions in their clinical treatments, and to discuss issues concerning integrating physical exercise in the treatment.
- U. K. Department of Health (Op. cit.): Physical activity is found effective in the treatment of clinical depression and can be as successful as psychotherapy or medication, particularly in the longer term. It may also help people with generalised anxiety disorders, and can have a positive effect on psychological well-being in people with schizophrenia. The possible mechanisms that would mediate this relationships are suggested to be the following: Biochemical, endorphins, norepinephrine, and serotonin.
- Monteiro and Silveira (2005) find that evidence indicates that moderate exercise improves mood (or helps maintain it at high levels), while intense exercise leads to its deterioration, and that these mood variations are more related to the construct of depression than to the construct of anxiety.
- Atkinson and Weigand (2008, june) analysed a few studies using walking as the physical activity that is measured against mental health benefits. The authors demonstrated that walking is a worthy mode by which to measure physical activity and it has the potential to provide mental health benefits.
- Taylor and Faulkner (2008) reviewed the evidence on the effects of physical activity on mental health in their inaugural editorial of the newly created journal “*Mental Health and Physical Activity*”. For these authors the research is moving towards very passionate ways: Bio-physical and psycho-social mechanisms are the mediators between engagement in physical activity and well-being. But the most rapid advances in understanding the mechanisms is pointed to come from the neuroscience field: neurogenerative, neuroadaptative and neuroprotective processes. Also the increasing popularity of relatively low intensity activity broadens the scope for understanding how physical activity influences mental health. Another of the issues to solve is the translation of scientific evidence into policies. A perfect example of how to do this comes from the National Institute of Clinical Excellence (UK) guidelines for exercise en the treatment of depression recommending to advice patients with mild depression of all ages to be advised of the benefits of following a structured program of exercise up to 3 sessions per week.

  Benefits attainable trough these practices would be either physiological or psychosocial:

  a) Physiological: temperature and cerebral blood flow increase, reduced muscular tension and neurotransmiter efficiency; and

b) Psychosocial, perceptions of competence, self-confidence in his/her own body and its capabilities, improving body image, experiences of achievement, etc…

- Whitelaw, Swift, Goodwin, and Clark (2008, May) make especial emphasis in different physical activity types, intensities, frequencies and durations in achieving this benefits. For example, compared to physiological benefit, lesser levels may be sufficient to achieve MH benefits.

Built environment and walkability

- Craig, Brownson, Cragg and Dunn. (2002) find positive association between the environment score and walking to work; controlling for degree of urbanization supports current movement toward the development of integrated communities. In this review the purpose of the trips turns to be of relevance.
- Owen, Humpel, Leslie, Bauman and Sallis. (2004, July) identified 18 studies. Aesthetics attributes, convenience of facilities for walking (sidewalks, trails); accessibility of destinations (stores, park, beach); and perceptions about traffic and busy roads were found to be associated with walking for particular purposes. Attributes associated with walking for exercise were different from those associated with walking to get to and from places.
- Badland and Schofield (2005, May) find that key features for PA related to transport are density, subdivision age, street connectivity and mixed land use. Their suggestion for future research includes: measurement tools, better understanding of traffic calming measures and collaborative work multidisciplinary.
- Duncan, Spence and Mummery. (2005) undertake a meta-analysis of reviews. Results support the relevance of perceived environmental characteristics in understanding population PA, like perceived presence of PA facilities, sidewalks, shops and services and traffic barriers. Walking and cycling was higher in neighbourhoods classified as transit orientated (higher connectivity) compared to neighbourhoods classified as automobile orientated.
- Sallis and Kerr (2006) find association between built environment and physical activity regarding active transport and Active Recreation. For active transport there are multiple findings of positive association with Walkability: mixed land use, street connectivity, residential density for adults and older adults, but a few findings of positive association for youth.
- Lovasi et al (2008) focuses in walking only for exercise, and found no associations with residential density or connectivity.

Built environment and health outcomes

- Truong and Ma (2006) carried out a systematic review of 29 studies published in English in peer reviewed journals, founds statistically significant association between mental health and at least one measure of neighbourhood characteristics, after adjusting for individual factors. This association was evident for all types of neighbourhood features.

  The authors concluded that evidence is highly consistent across studies but the reality is complex. Only two studies used randomized and controlled trials and causal effects should be interpreted with caution. Following the authors more attention has to be paid to neighbourhood–level of intervention. The authors suggest that policy makers may want to incorporate mental health as a measure for evaluating improvements programs.
- Mair, Diez, Roux and Galea (2008) reviewed 45 studies, 37 of them reported association of at least one neighbourhood characteristic with depression or depressive symptoms after controlling for individual level characteristics, measures of the built environment appeared to be more consistently associated with depression that socio-economic deprivation, residential stability or race composition.

Discussion

The questions raised shed light upon fundamental quality of life and well-being considerations including residential preferences, time use, space requirements, security, and convenience, which collectively shape the built environment. The ability to move by human means has been shifted to the car for sake of a relative cost-benefits analysis of dwelling, travelling and lifestyles choices. Transport and dwelling decisions have to do with social and economic arguments, but cognitions plays an important role in the cost benefits equation. Little by little the contemporary cost-benefits equation shows signs of being out of date. The Walking activity links with physical and mental health are progressive uncovered. Walking has an added value (Cavill, 2001): enjoyment of scenery, escape from dull work, good company, good talk, etc. We may say that the new knowledge on PA related to MH and Built form claims for a new readjustment of the cost-benefit equation parameters.

The studied literature has shown that there is evidence that physical activity, even mental health objectives can be reached, though it was rather controversial. Finally we have got some evidence that even low intensity levels of exercise like walking, like 4-6 km/h (Ainsworth, 2002), have the power to enhance and maintain mental health and – what results more interesting- it can be done in short bouts tailored to distances and spaces appropriated for modern-age people, let's say: one mile (Hall, 2000). That opens up potential for both mental health and well-being for all.

It must be understood that methodological problems are not easy to remove; the mechanisms that link PA and health are still uncovered statistically. There is also a practical question: can the built environment by itself promote or become associated to walking activity? It seems that the answer is affirmative. Furthermore: what about the association between built environment and mental health? Why mental health and not just physical health outcomes? According to WHO (2001) mental health is central for a healthy life mental health. Here again there are methodological problems: what are the relevant variables and how can they be measured? Meanwhile, in certain expectation that we will find more humane friendly and balanced, mixed-use environments and integrative communities, it is planning strategies' turn now.

Conclusion

We have carried out a review of recent literature (years 2000 to 2008) relating physical activity (PA) and mental health (MH) with the Built environment. Evidence suggests that certain levels and intensities of walking, even moderate and low levels of PA, are beneficial to modern-age people, clinical and sub clinical disorders, and that mental health including well-being benefits are also associated low levels of activity. The built environment has the potential to foster these behaviours from the supportive neighbourhood characteristics, liveable streets and other pedestrian friendly environments. Finally some early signs of evidence are showing up that mental health outcomes are also associated with built environment features, although methodological problems still remain to be solved.

3.1.2 Barriers in pedestrians' Mobility

Pedestrian and cyclist safety received increasing attention. To date the majority of road networks and urban developments have been designed primarily for vehicles and little consideration was give to pedestrians and cyclists. This was justified by the belief that most of the trips are made by vehicular means of transport. Thus, implicitly the mobility of vulnerable road users and their physical health is suppressed more than the rest users of road network. As it was mentioned above, pedestrians' mobility restrained by inadequate infrastructure such as:

- inadequate or absence of pavements.
- inadequate or absence of pedestrian crossings.

- inadequate or absence of ramps and special infrastructure for disabled.
- inadequate connection with Public Transport nodes.
- inadequate or absence of special infrastructure for people with disabilities such as blind persons (i.e. in many cases vehicles are parked on the special surface on the pavement which is dedicated to the movement of blind people).
- inadequate or absence of pedestrian information systems, etc.
- Different things such as: lightings, traffic signs, telephone boxes, buckets, street furniture, trees, sidewalk café, etc.

According to surveys which carried out in Austria, a sidewalk café can pose big problems for pedestrians due to the reduced width of pavements by cafes' furniture. This is also documented by surveys carried out in Greece where (Komnianou, D., et al, 2008) cafes' furniture is considered as one of the main barriers (60%) in pedestrians' mobility on pedestrians' streets (Figure 1).

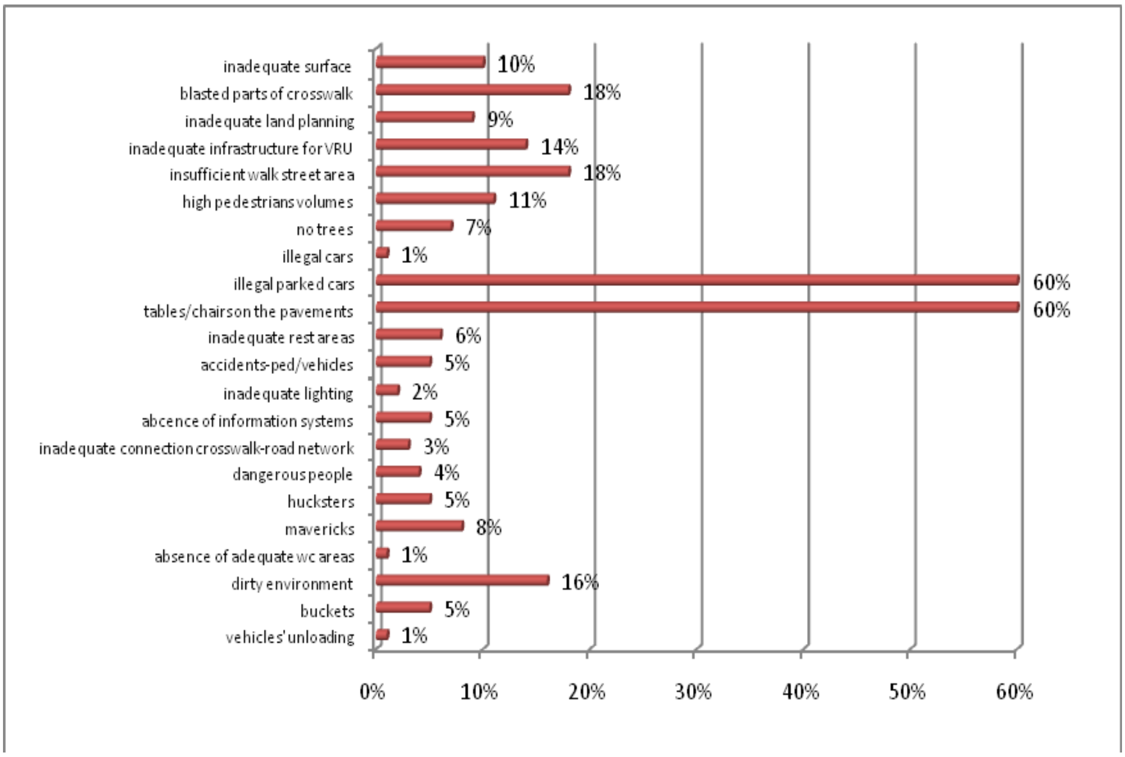

Figure 1 Obstacles during walking (Komnianou, D., et al, 2008)

Additionally, the mobility of pedestrians influenced according to wealth factors such as:

a) Socioeconomic and infrastructure characteristics of the areas where pedestrians make their trips:
   - areas with poor infrastructure for pedestrians (e.g. no or small pavements, high traffic volume but no safe crossing possibilities), as a result they use other transport mode in order to reach their destinations.
   - areas with poor means of public transport.
   - industrial areas (areas where walking is often unattractive).
   - commercial areas (safe, stairs, mixed traffic, crosswalks etc.).

b) Abilities and opportunities based on the individual economic situation (personal wealth):
   - alternative ways of transportation (especially people with high/average income).
   - change of destinations (for certain trip purposes) in case that the environment for the pedestrians is not attractive.

According to the results from the survey in Thessaloniki (Komnianou, D., et al, 2008), Greece income affects car use: people with high incomes use the car more (90%) than people with lower income (Figure 2).

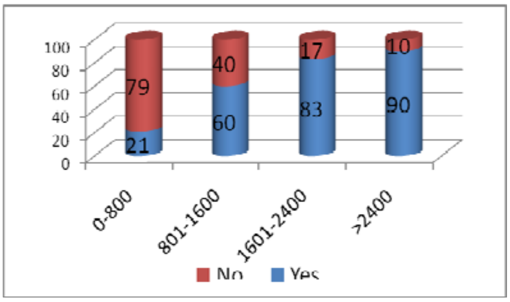

Figure 2 Obstacles during walking (Komnianou, D., et al, 2008)

3.1.3 Physical and safety needs which are being involved - Consequences of their involvement

The physical and safety needs which concern pedestrians' mobility are:

- Physical health (i.e. ability to walk).
- Safe and security (adequate infrastructure, lighting, visibility, traffic signs).

3.1.3.1 Physical Health

As mentioned above the ability to walk is influenced by the physical health and the qualities of the infrastructure. This is particularly true for people who have physical health problems (i.e. younger, the elderly, people with any kind of disabilities, deaf, blind, impaired, etc).

3.1.3.2 Safe and Security

The feeling of safety and security is an important determinant for peoples' travel and sojourn decisions. According to the results from an American telephone survey which was carried out [15] in October 2002, by Belden Russonello & Stewart, (national random sample of 800 adults, age 18 and older from October 23 to 30, 2002). Americans would like to walk more but speeding and inadequate infrastructure such as dangerous intersections discouraged them. The survey propose people to walk by introducing specific policies such as "*designing streets for slower traffic speeds; using more money to make walking safer from traffic; and creating walking-friendly routes to school for children*".

Americans appear to support policies to make walking safer and easier. 86% of Americans desire better enforcement of traffic laws, such as speed limits (57% strongly in favour). Over eight in ten (84%) desire more money for the transportation in order to design streets with sidewalks, safe crossing and other devices to reduce speeding in residential areas and make it safer to walk, this means driving more slowly (48% strongly). Three-quarters (74%) stated "*using part of the state transportation budget to create more sidewalks and stop signs in communities, to make it safer and easier for children to walk to school, even if this means less money to build new highways (41% strongly)*".

3.1.3.3 Consequences

The consequences of an inadequate physical and safety pedestrian needs are:

- Unfriendly "walking environment".
- Increase of accidents in which pedestrians are involved.
- Fear of walking.
- Blockade VRU from the society.
- Economic implications for the individuals.
- Economic implications for the society (i.e. less shopping).

Some examples of unfriendly walking environment are presented in Figure 3.

Figure 3 Unfriendly walking environments (Komnianou, D., et al, 2008)

3.1.4 Improvements-deteriorations of the situation

In order to improve the situation of walking environment for helping pedestrians, new different measures should be taken into consideration such as:

- *"Give priority" measures for pedestrians* near areas (i.e. shopping centres) which attract high pedestrian volumes (i.e. zebra crossings, pelican crossings, control of crossings' waiting times, crossing times, information technology, speed limits reduction, etc.).
- Implementation of *traffic calming measures* near school areas (e.g. humps, continuous pavements at crossings, etc.).

The Danish Road Directorate has developed a guide which involves measures for reducing speeds through urban areas by using design factors, (Herrstedt, L., et al, 1993). A European Community project called Developing Urban Management and Safety (DUMAS), examined speed management in urban areas in Denmark, Netherlands and England. The results can be found in a report published by the Danish Road Directorate, (Greibe, P. and Nilsson, P. 1999), (Greibe, P., Nilsson, P., and Herrstedt, L. 1999). Additionally, the Department of the Environment in the United Kingdom has developed a series of leaflets that summarize concepts, principles, and examples of traffic calming devices. Such practices have been implemented in urban areas in order to reduce speeds, (Department of the Environment, 1999):

- "*Pre-warnings: typically lines on the pavement with (rumble strips) or without punishment (lines and traffic signs);*
- *Gates: typically different pavement colour or structures that indicate transition between traffic environments, often augmented with signs and landscaping;*
- *Narrowings: typically the available travelway width is reduced to narrower lane widths with the addition of islands, by eliminating one lane in two-lane roads or by using wider edge markings;*

- *Humps and tables: with varied profiles including circular, sinusoidal, dome-shaped, or trapezoidal cross-sections and varied lengths depending upon the desired speed reduction;*
- *Raised areas: typically a trapezoidal hump with extended length to allow for longer vehicles to have all wheels on them;*
- *Staggering: typically a lane is shifted over;*
- *Roundabouts: typically used as gates for speed reduction; For example, a Danish study of 201 roundabouts showed a 71 percent reduction in injury crashes after the installation of roundabouts, while a Swedish study of 21 urban intersections showed a 35 percent reduction in injury crashes after the installation* (Greibe, P., Nilsson, P., and Herrstedt, L. 1999).
- *Chicanes: typically extensions of the curb at intersections to reduce approach lane widths;*
- *Islands: typically raised elements along the centreline of the roadway to shelter pedestrians and ease street crossing;*
- *Cushions: typically square humps in each travel lane;*
- *Landscaping and plantings: typically use of vegetation as gates, as a means to visually reduce lane widths or as methods to enforce other traffic calming components; and*
- *Pavement textures and colours: typically use of stones or pavers to visually separate roadway elements, and use of colours to enforce concepts or mark transitions between roadway environments*".

Other measures for improving pedestrians' environment include:

- Improvements of walking infrastructure (i.e. sidewalks widening, quality of materials, tactile guidelines for blind people) and walking environment (lighting, noise, fumes, street furniture, green elements, flowers, etc.).
- Pedestrianisation schemes.
- Woonerf areas (30 km/h).
- Improvement of the Public Transportation system (e.g. availability, accessibility, waiting time, frequency, information, vehicles, priority measures etc.) and the connection of Public Transport system with the pedestrian network.
- Advanced Safety Technologies, including Intelligent Transportation Systems (ITS) for pedestrians' safety (e.g. pedestrian detectors), provision of information etc.
- Avoidance of mixed traffic, (shared space would be for some a positive example for mixed traffic (e.g. of mixed cycle and pedestrian paths; in Austrian studies mixed cycle and pedestrian paths are mentioned very often as a problem by pedestrians and cyclists)).
- Special policy for disabled such as: tactile cones near or under the control button, tactile surfacing pattern (or tactile paving), audible signals such as beeps, in order to help blind or partially-sighted pedestrians, short recorded message, a vibrating button in addition to an audible signal to assist hearing-impaired and electrostatic, touch-sensitive buttons.

Unfriendly "walking environment" restrains the mobility of pedestrians, especially for vulnerable groups of persons, in some cases even leading to social exclusion. For these reasons an additional research should carried out to examine what barriers to pedestrians' safe mobility exist, especially for vulnerable persons, and what ways there are for improvement so that the walking environment becomes more attractive for all persons.

The implementation of traffic calming measures leads to the reduction of accidents (more than 60 percent in some cases in Denmark and England). It should be mentioned at this point that the most effective traffic calming means are speed humps, "*but they require precision in design and construction to achieve a comfortable ride when traversed at the desired speeds*" (Kjemtrup, K. 1988). Finally, *"significant differences in safety gains are* *realized by various types of road users, with passenger car users having the highest gains and pedestrians and bicyclists having the lowest. Roundabouts can also improve intersection capacity over signalization; those with single-lane approaches seem to perform very well, with volumes of up to 2,500 vehicles per hour"*, (*FHWA*).

3.2 How one's social context determines travels and sojourn decisions

3.2.1 Fundamental groups (of pedestrians) which can be distinguished with regard to social context

It is not yet very clear how travel decisions are made. It appears that the ***"social context"*** of people can determine their travel and sojourn decisions. There seem to be many reasons affecting one's decisions: the employment situation, family situation, collective needs, etc. For example, if someone works far away from his home, he/she is compelled to use different types of vehicles for reaching his/her destination in time. Another factor which can determine one's travel decisions is his/her family situation: if he/she owns a vehicle, he/she will probably prefer to use vehicle so that he/she can travel to his/her destinations easier and quicker. For all these reasons it should be examined how one's situation affects his/her travel-sojourn decisions, to find ways for improving the situation in order people reach their destinations on foot. Specific factors and groups which affecting travel and sojourn decisions are:

- Car availability (leads people to use their private car for their trips).
- Availability of other transport modes (i.e. bicycle, motorcycle) in conjunction with the respective infrastructure provided in the area where pedestrian activities take place.
- Public Transport availability in conjunction with the type of area where people live and work.
- Social-collective needs (i.e. friends, shopping, health etc).
- Other activities (i.e. participation to activities of general social interest).

The different groups which can be distinguished with regard to social context are:

- Family situation; size and structure of the household.
- Income situation; people with high/average/low (family or personal) income. In the case of vehicle owner, he/she will prefer to use vehicle in order to move to his/her destinations easier and quicker.
- Education level. In some cases, people with high education level are aware of walking benefits than lower education levels.
- Employment. If someone works far away from home, he/she will move by private or public vehicles in order to reach his/her destination.

3.2.1.1 Car availability

Car availability is an important factor which determines travel decisions with regard to walking. "*As the number of cars in a household increases, the total number of trips made per person per day by all transport modes increases as a result of an increase in car trips*", (CA O' Flaherty, 1997). If a car adding to an urban household, this means *"4 additional trips are made by car per day for a first car and about 3 for a second car; at the same time trips by other modes and especially trips by foot are lost"*. A society based on vehicular traffic can make life extremely difficult for people who are unable to use vehicular modes of transport such as children, elder, disabled.

3.2.1.2 Availability of other transport modes

The availability of other transport modes (i.e. bicycle, motorcycle) in conjunction with the respective infrastructure provided in the area where pedestrian activities take place is another factor which influence travel decisions. Cycle and motorcycle travel are more important in smaller cities or where the use of Public Transport is low. In this case bicycles and motorcycles not only replace walking but many times the users of mopeds use pedestrian infrastructure in order to move to their destination easier and quicker depriving pedestrians from their area.

3.2.1.3 Public Transport availability
Public Transport availability in conjunction with the type of area where people live and work is another factor which plays crucial role in travel decisions. In general Public Transport means are more practical in large cities. The Public Transport system is adequate near shopping and offices areas and usually poor in outskirts of the cities and rural areas. Car availability is the factor which influences the use of means of Public Transport. An analysis of travel data from British towns, (CA O' Flaherty, 1997) shown that "*if the level of Public Transport is good then the car ownership levels reduced by 0.04-0.06 car per year person*". This means that walking will increase because relatively large numbers of people using Public Transport.

3.2.1.4 Social-collective needs (i.e. friends, shopping, health etc) **- Other activities** (i.e. participation to activities of general social interest)

Experts' opinions about people's social-collective needs and activities which consider their decisions to walking are (Rodney Tolley et al, 2001):

- **Changes in patterns of leisure:** *just walking in peoples' leisure time is not trendy, better to visit a fitness-centre.*
- **Lifestyle:** *A reduction in the need to travel* (and the status of travel), linked to new technologies and patterns of activity: initiative at the local level including widespread use of virtual/IT services will see a decentralising effect to support local (urban/rural) communities.
- Experts said: *a computer and a mobile phone will replace a car as a status symbol. There are many changes in patterns of leisure - young people are spending more time in front of TV, internet etc. which means slight decrease in walking.* Changing activity patterns also indicated quite contradictory patterns of walking.
- New hobbies and ways to use leisure time take more often place far away from home, which means that a car and Public Transport are more often used. *The growing pace of modern life* produced contradictory views on the impacts for walking. On the one hand, some experts were positive: I see a counter movement in lifestyle coming in this decade. On the other hand, more were orientated towards a decline in walking, identifying a lack of time as a key issue: *Faster pace of life, lack of time, greater affluence will all reduce amount of time walking,* (Rodney Tolley et al, 2001).

3.2.1.5 Family situation
The size and the structure of the household is an important factor to influence walking decisions. There many households up to 3 members which have only one car. As a result some members of the family do not have the opportunity to use the car, forcing them to use other means of transport, and to walk more. Figures 4 and 5 present the car usage. As it can be easily noticed, while 113 persons have car in their household, only 63 of them are use car (Aristotle University of Thessaloniki, 2007).

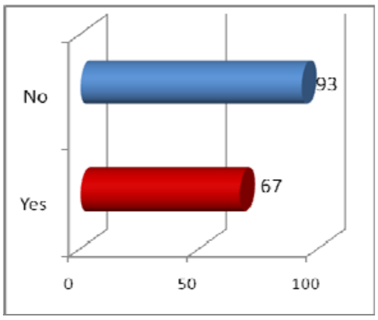

Figure 4 Car Usage

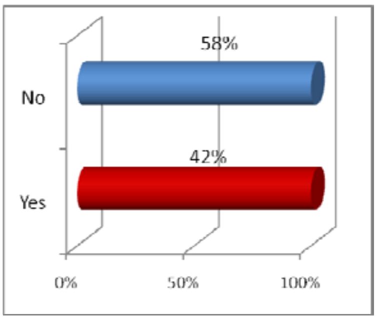

Figure 5 Car Usage (%)

3.2.1.6 Income situation

Income situation can vary. There are people with high/average/low (family or personal) income. Vehicle owners, mostly average/high income people, will prefer to use vehicles to move to his/her destinations easier and quicker. At this point it should be said that the increase of the car ownership rate in a country is mostly determined by economic conditions and growth. In high economic growth societies more transport modes are more abundantly available than poor countries. The relationship between the use of car and income is demonstrated by Figure 4 where people with higher income use car more than lower income groups.

On the other hand, in poor countries generally no adequate pedestrian facilities are offered; as a result high accidents levels are observed. Another factor is the place where someone lives. In most cases this depends on the income. For example, "*inner London residents make nearly 60% more walking journeys than the average for the residents of rural areas. Although the differences are small, the number of walk trips per year generally increases with the size of the urban area"* (Department for Transport 1998).

3.2.1.7 Education level

According to research carried out in Thessaloniki's city centre ((Komnianou, D., et al, 2008), people with high education level are more aware of walking benefits than those of lower education levels. Figure 6 presents the knowledge of walking benefits in terms of education level. As it noticed, people who have bachelor (34%) or master degree (33%) are more informed about walking benefits than other education level groups.

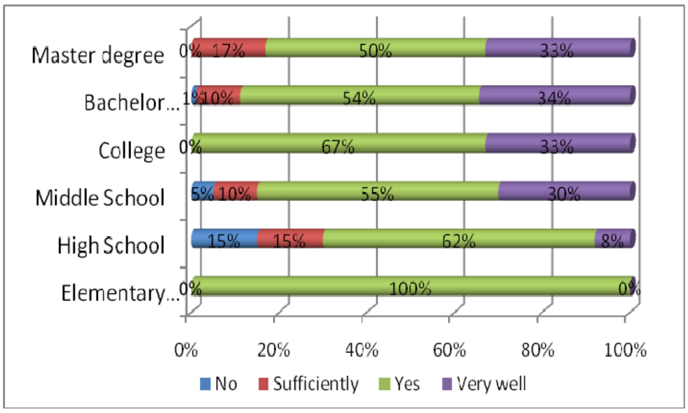

Figure 6 Knowledge of walking benefits in terms of education level

3.2.2 Social Barriers in pedestrians' mobility

There are many barriers to pedestrians' mobility. The main barriers during their trips are:

Availability of private transport modes

As it was mentioned above, if someone has a private vehicle, he/she probably can reach his/her destination easier and quicker than on foot or using PT.

Adequate access to the Public Transport system

Only if the access to the Public Transport system is adequate (waiting time, frequency, travel time, reliability, cost) then people will prefer to use means of Public Transport and walking for their trips (i.e. bus and walk). According to a research which took place in the city of Katerini, Greece (Aristotle University of Thessaloniki, 2007), the main reasons of dissatisfaction towards the quality of PT include the large waiting time (22%) and drivers' behaviour (22%).

Long distances between origin–destination of daily/weekly trips (i.e. residence-employment).

The long distance between origin-destinations is a factor discouraging people to make their trips as pedestrians. If it takes someone a long time in order to reach his/her destination on foot, he/she will not prefer to move on foot, because "lost of time" means "lost of money". Figure 7 presents the main reason for which people not walk. As it is noticed, long distance (30%) is the most important reason which prevents people from walking (Komnianou, D., et al, 2008).

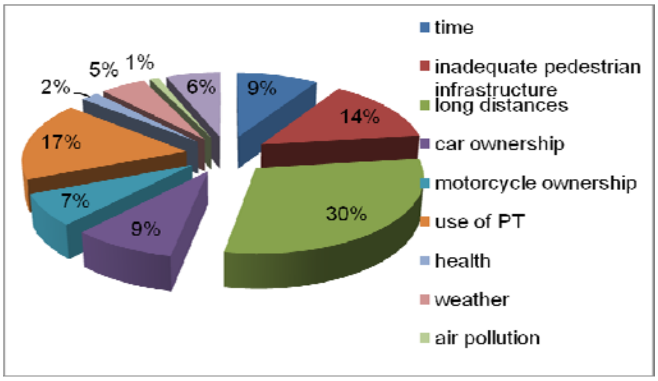

Figure 7 Main reasons for which people prefer not walk

Environment (i.e. safety, security, aesthetics, traffic noise, emissions, severance effect) - Infrastructure provided for the facilitation of pedestrian trips

The place where someone lives and works plays a crucial role in his/her travel decisions. For example areas with adequate pedestrianisation schemes and good quality of pedestrian environment attract people and make them to change their daily habits by replacing vehicular modes by foot.

Safety-Security

It is well documented that people quite often change the way they travel because of fears for their personal security. People consider walking to be the least safe way to travel and fear of crime is a significant factor which makes walking a very difficult task. The British Crime Survey analysis (Hough, M, 1994) reveals that "*significant minorities routinely avoid going out alone after dark or avoid certain areas or types of people because of fears for their personal security*". In addition, men are less anxious than women about their personal security. Recent research has also confirmed that the fear of people for their personal security disturb them to use means of Public Transport (DETR, 1995).

Additionally, the feeling of safety during walking is an important factor affecting peoples' travel decisions. Recent research in Greek town (Katerini) shown that 31% of pedestrians feel unsafe during their trip by foot (Aristotle University of Thessaloniki, 2007), Figure 8.

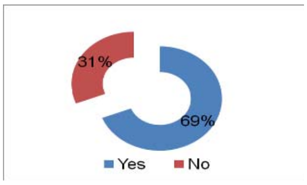

Figure 8 Feeling of Safety

The main reason of unsafety is the drivers' behavior (41%) and the absence of adequate infrastructure for pedestrians (17%), Figure 9.

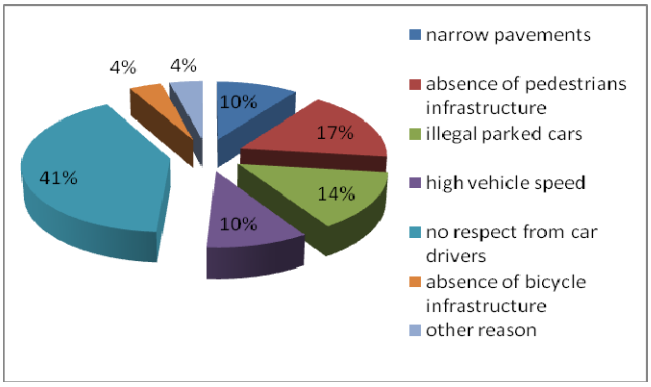

Figure 9 Reasons of unsafety (Komnianou, D.,et al, 2008)

In addition, the children's walking trips are reduced due to parents' fear for their children's safety and security (Sustrans, 1996). Children usually identify that heavy traffic make their walking trip to school difficult; while in a recent survey amongst schools in Hereford and Worcester, only 2% of students identified risks from strangers as a reason not to walk (Hereford and Worcester Council, 1996).

Traffic Noise
Noise from vehicles disturbs sleep, makes working difficult, cause difficulties to the learning, hinders social activity and "*affects health through stress generated by frustration from lack of sleep and general deterioration in the quality of life*" (CA O' Flaherty, 1997).

In Italy and Austria, traffic noise and fuel emissions are mentioned as main factors which deter people to walk more frequently.

Emissions
The main emissions from motor vehicles are carbon dioxide (CO_2) and air pollutants: carbon monoxide (CO), nitrogen oxides (NO_x), oxide of sulphur (SO_x), hydrocarbons (HC) and other particulate matters. Vehicle emissions can cause various health problems, e.g. respiratory problems. The need to control emissions from vehicles is recognized and many countries made an attempt in order to control the levels of emissions.

Severance Effect
Research carried out by Pigou and Liepman (Guo, X, Black, J, Dunne, M 2001) showed the impact of severance: *"Initially, severance was applied to the increasing separation of homes and workplaces and the adverse effects of the development of the dormitory suburb and the journey to work. These matters were raised in the early studies of town planning and urban development by Pigou and articulated convincingly by Liepmann. With urban expressway construction, the definition shifted to one of severance as a physical barrier to community interaction. Later, the definition broadened so that severance not only involved physical separation, but also included other undesirable impacts such as visual effects of road structures, and pedestrian delay"*. In more recent studies, "*community severance was applied to physical separation, and incorporated psychological and cultural impacts. The meaning of*

severance has now extended into social impact and human perception. Thus, the conceptualisation of the severance problem in current terminology has two components: static severance (SS) of the road infrastructure as a barrier to the community, and dynamic severance (DS) caused by the flow of vehicles along the road to those pedestrians crossing that road" (Guo, X, Black, J, Dunne, M, 2001).

Pedestrian Infrastructure

Pedestrian infrastructure-facilities are one of the main reasons which may attract pedestrians. Studies by the Pedestrian Association reveal that poor pavement surfaces and fear of falling can be a significant deterrent to people on foot, especially for older people. Walk-activity patterns significantly vary between neighbourhoods with different accessibility characteristics. "*In the physically accessible neighbourhoods, walks are predominantly short and frequent utilitarian trips that involve more secondary activities. Activity in the less accessible neighbourhoods; is characterised by longer, less frequent recreational walks that involve fewer secondary activities*" (Katherine Shriver, 1997).

3.2.3 Improvements-deteriorations of the situation

According to research which is carried out worldwide, the most important factors which can improve the situation in order that more people make their daily trips on foot include:

- Improvements of the Public Transportation system.
- Relocation of land uses (i.e. residence, work).
- Change of daily habits (i.e. shopping).
- Improvement of residence and work areas in order to promote "walking" (in terms of infrastructure, facilities etc.).
- Provision of motives as far as walking is concerned (i.e. health benefits).
- Campaigns and education (i.e. environmental benefits).

Relocation

A main factor in order to improve/promote walking is the relocation (i.e. residence, work). According to a research which made in Chinese cities in terms of the transportation impacts of the changing workplace-residence relationship using Beijing as the study case results that: "*evidence from a 1996 housing relocation survey indicates that commuting time increases by 30% as households move away from previous housing locations and from central districts to suburban districts. This finding partially explains the demand for motorized transportation and the congestion in today's Chinese cities*", (Jiawen Yang, 2006). Relocation can reduce motorised travel if peoples' homes are near their work or live in areas which offer adequate Public Transport system.

Change of daily habits

In order to change peoples' daily habits a provision of benefits as far as walking is concerned (i.e. health benefits) is necessary. According to the US FWHA this can be achieved by (http://safety.fhwa.dot.gov/index.htm):

- *Campaigns and education (i.e. environmental benefits).*
- *Deliver important safety messages through various print and electronic media.*
- *Improve existing traffic laws, as well as their enforcement.*
- *Reduce the incidence of serious crimes against non-motorized travelers.*
- *Use non-motorized modes to help accomplish other unrelated departmental goals.*
- *Reduce or eliminate disincentives for bicycling and walking and incentives for driving single-occupant motor vehicles.*
- *Provide ways for non-participants to receive a casual introduction to bicycling and walking.*

- *Use electronic and print media to spread information on the benefits of non-motorized travel.*

After the campaigns people will be aware about walking benefits and will change their daily habits (i.e. shopping) by increasing their daily walking time (http://safety.fhwa.dot.gov/index.htm).

Improvement of residence and work areas
Improvements of residence and work areas is a good way in order to promote “walking” (in terms of infrastructure, facilities etc.). Some of these ways are:

Walking distance: *is an important design aspect, since the shorter, the journey distance, the higher the probability that it will made on foot. It has been found that over 60 percent of all journeys under 1.5 km are made on foot, and that pedestrian journeys rarely exceed 3 km in length. This means that if walking is to be encouraged, then the distance between (e.g. home) and destinations (e.g. shops) should preferably be less than 1 km* (CA O’ Flaherty, 1997).

Seating*: the provision of seating is an important design feature. Seating should be in the right place functional, of robust design, aesthetically pleasing and having a low maintenance requirement* (CA O’ Flaherty, 1997).

Walking surface quality: *it should be ensured that walking surface is adequate and safe for pedestrians. Additionally, is important the establishment of special infrastructure for disabled people*.

Information needs: *it is necessary for elderly and disabled people. There are two types:*

- *directional information in order to reach a specific destination (signs) and*
- *information on when it is safe to cross the road (tactile signals, audible signals).*

Special infrastructure for elderly and disabled people*: such as ramp gradients, steps and street furniture (including seating).*

Figure 10 presents the pedestrians proposal in order improve the walking environment according the research carried out in Thessaloniki (Komnianou, D., et al, 2008). As it can be seen, pedestrians want vehicles removal (44%), parked vehicles removal (39%), more trees (32%), adequate infrastructure for walking (24%), clean environment (24%) and reduction of tables and chairs belonging to cafes from the pavements and walk streets (24%).

3.3 Land Use and Physical Environmental characteristics determine travel and sojourn decisions with regard to walking

Land Use and Physical Environmental characteristics determine travel and sojourn decisions with regard to walking such as: distance, building density and type, barriers, slope, height differences, atmospheric conditions, user/environment interface, demand/offer, etc.

3.3.1 The most important Land use and Physical Environmental factors

Distance

One of the most important factors in a person's decision to walk or bike is the proximity of goods and services to homes and workplaces. A recent study for the Federal Highway Administration includes the following: 33 percent of survey respondents cited distance as the primary reason for not walking. When someone should travel a long distance in order to reach to his/her destination, he/she will prefer to use vehicles rather than to move by foot in order to save time/save money. According to an American survey, distance and time are seen as main barriers to people walking more. The main reasons which Americans report not walking more are: “things are too far to get to” (61% a reason for not walking more) and they “do not have enough time” (57%).

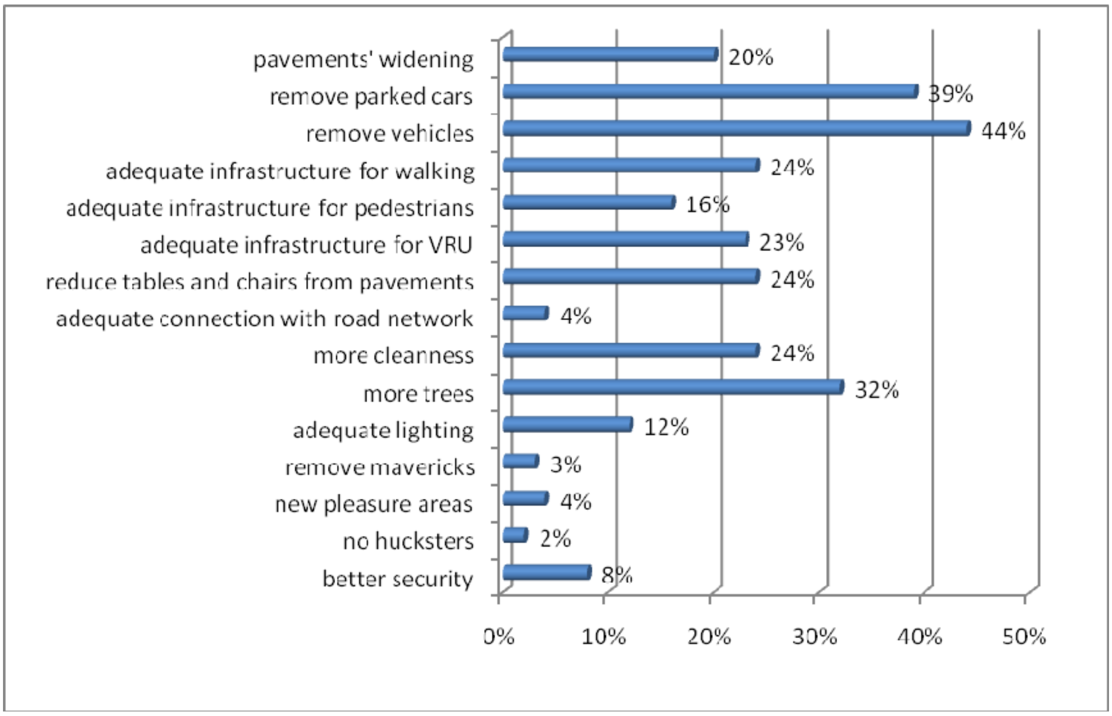

Figure 10 Pedestrians’ proposals (Komnianou, D.,et al, 2008)

Types of Land Use

Areas which concentrate a large number of different land uses such as shopping, bars, monuments, tourist areas, etc. generally attract high volumes of pedestrians (in such areas, people prefer to walk rather than to use vehicles). In most cases these areas have adequate infrastructure for pedestrians in order to attract new pedestrians.

Building density

Walking is impeded by Building density which make the walking environment more and more unattractive. On the other hand, “*transit use, walking and biking increase with density and land use mix as shorter trips makes them possible”* (DETR, 1995), Figure 11.

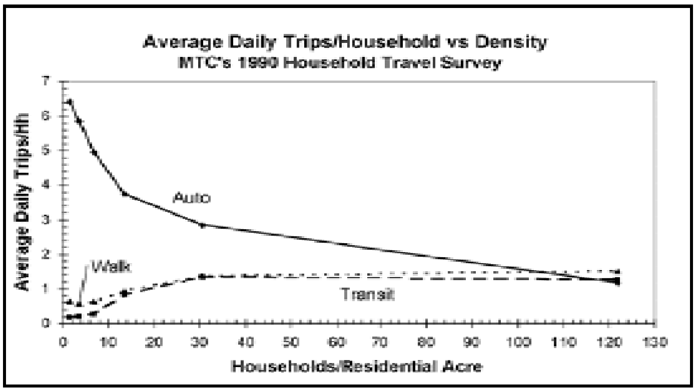

Figure 11 Average Daily Trips/Household vs Density (DETR, 1995)

Studies have also shown that more people walk in areas that are able to achieve higher densities of either housing or employment, despite lower densities of other uses such as retail. One study of the Puget Sound Region in Washington State defines “*high density as 50 to 75 employees per acre, or 9 to 18 residents per acre*” (http://safety.fhwa.dot.gov/index.htm).

According to a survey, which carried out in US, results that density is associated with the purpose of walking (travel, leisure) but not the amount of overall walking or overall physical activity, although there are sub-group differences by race/ ethnicity. *“Overall, higher densities have many benefits in terms of efficient use of infrastructure, housing affordability, energy efficiency and possibly vibrant street life. But higher densities alone, like other built environment features, do not appear to be the silver bullet in the public health campaign to increase physical activity”* (Ann Forsyth, J. Michael Oakes, 2007).

Obstacles during walking
Pedestrians deal with many obstacles during their trip such as: high traffic volumes, absence of inadequate infrastructure especially near areas which concentrate high volumes of pedestrians (shops, parks, café, bars etc) which “push” pedestrians off from the road network (Figure 12).

Figure 12 Obstacles during walking (Komnianou, D., et al, 2008)

Atmospheric conditions
As it was mentioned above, an atmospheric condition is a factor which determines pedestrians’ travel-sojourn decisions. High traffic volumes lead to air pollution due to fuel emissions. This fact is the reason of problems of peoples’ health such as respiratory and cardiovascular problems.

The most important Land Use factors and Environmental characteristics
According to survey which made from students of Aristotle University of Thessaloniki (Komnianou, D., et al, 2008), the most important factors which affect travel and sojourn decisions are:

- ***Long distances*** in order to perform various activities.
- ***Building*** and ***road network density***.
- Absence of ***adequate infrastructure*** (i.e. pedestrian streets, pedestrian crossings, woonerven).
- ***Trip generation rates*** produced by the variety of land uses in an area.
- ***Obstacles*** in the road network (i.e. illegal parking, inadequate street furniture).
- High volumes of ***vehicles***.
- High volumes of ***pedestrians***.
- ***Conflict points*** between pedestrians and vehicular traffic.
- ***Environmental conditions*** due to ***traffic*** (emissions, visual intrusion, traffic noise, aesthetics, road safety etc).
- ***Environmental conditions*** due to ***build environment*** (i.e. narrow streets, absence of open space, narrow sidewalks).

3.3.2 Strength of the relationship

How these factors affect “walking” decisions

The factors which are mentioned above affect walking decisions and as a result walking become more and more unattractive (use of alternative transport modes instead – i.e. vehicular means of transport). Consequently people change their destinations, their habits and their daily time schedule (i.e. working hours if possible) in order to ensure comfort in their trips.

Examination of the relationship

In order to examine the relationship between the Land use and Environmental factors which determine walking decisions experts can use:

- Mathematical approach (establishment of relationships between walking and various factors affecting walking). Models as a result of the Mathematical approach.
- Land-use transport interaction models.
- Qualitative approach (ask people, observe people).

The basic land use-physical environmental characteristics which affect pedestrians’ travel decisions can be as follows: People prefer to move to their destinations by vehicles or they are have to use vehicles due to unacceptable walking conditions? After the determination of the most important factors the strengthen of the relationship between the characteristics and the travel-sojourn decisions should be examined. For example the city centre which concentrates the majority of land uses attracts more pedestrians rather than a super market out of city centre. The final relationship maybe will be in a form of a linear function: $y=a_0 + a_1 x_1 + a_2x_2 + a_3 x_{3.....} + a_n x_n$ where y will be the travel-sojourn decision and $x_{1,}$ $x_{2,}$ x_n the strongest characteristics which affect peoples’ decisions should be found. After the determination of the relationship the “threshold values” with regard to go-no go decisions. This could be done by using a statistical program (i.e. SPSS).

3.3.3 The relation of outcome with other factors and mechanisms

There are other factors and mechanisms which consider walking decisions such as:

Design of Transport Demand Measures (TDM)

As it is known, Transportation Demand Management or Travel Demand Management (both TDM) “*is the application of strategies and policies to influence traveler behavior with the aim of reducing automobile travel demand, or redistributing this demand in space or in time*” (Nelson et al, 2000). There is a broad range of TDM measures, especially for pedestrians:

- *Including or improving **pedestrian-oriented** design elements, such as short pedestrian crossings, wide sidewalks and street trees.*
- *Including and improving **public transportation** infrastructure, such as subway entrances, bus stops and routes.*
- ***Bicycle-friendly** facilities and environments, including secure bike storage areas and showers.*
- *Workplace **travel plans***

***Roadspace reallocation**, aiming to re-balance provision between private cars which often predominate due to high spatial allocations for roadside parking, and for sustainable modes (http://en.wikipedia.org/wiki/Transportation).*

If TDM will be introduced successfully, “*communities will be friendlier for walking due to lower traffic congestion, fewer emissions, improved public health and safety, greater economic competitiveness, and increased flexibility in the face of fossil fuel shortages. These are the well known benefits of sustainable transportation. Generally, TDM maximises personal* *mobility choices by ensuring that individuals are aware of their travel options, understand how to use them, and are willing to do so*" (www.tc.gc.ca).

Design of land-use policy
The design of land-use is an important factor which influences decision of walking. As is known, Land use and transportation have an extremely complex relationship. land use policies and programs that support active living can include: mixed-use development; transit-oriented development; brownfield redevelopment; urban infill; parks, recreation and trails; and school sitting (Healthy Community Design, 2005, www.Railtrail.org, www.activelivingresearch.org, http://www.ncsl.org/programs/environ/brownfields/brownfields.htm.

Design of an integrated environmental policy
"*Environmental Management is not, as the phrase could suggest the management of the environment as such, but rather the management of interaction by the modern human societies with, and impact upon the environment*" (http//en.wikipedia.org).

Set of priorities and budget allocation
The priorities and budget allocation in order to improve and subsidize measures of walking infrastructure and pedestrianisation schemes should be examined by the respective authorities.

Design of policies for special population groups (i.e. people with special needs)
Special consideration should be given to the vulnerable road users and to the existing infrastructure in order to provide them by new ramps, street furniture and special systems (push buttons, etc).

3.3.4 The threshold values with regard to go-no go decisions

There have been researches in order to take the threshold values for pedestrians needs. Some of threshold values are (Highway Capacity Manual):

3.3.4.1 Infrastructure for the pedestrians – Indicative and not exclusive list of values

- *Grades*: less than 10%.
- *Safeguarding average speed* for the pedestrians: 0.76 m/s (platoon: not less than 1.2 m/s).
- *Density*: 0.6 m^2/pedestrian which means Level of Service (LOS) F.

3.3.4.2 Level of Service (LOS) F thresholds for platoon flow in transportation terminals :

- Space: ≤ 0.7 m^2/pedestrian.
- Flow rate (ped/min/m): ≤ 57.
- Speed (m/s): ≤ 0.7.

Pedestrian delay at midblock crossings (values in UK):

- Zebra: 1.4 seconds.
- Fixed-time pelican: 10.1 seconds.
- Vehicle-actuated pelican: 9.8 seconds.

Maximum pedestrian delay at signalized intersections (UK): 30 seconds
Density of crosswalks: number of crosswalks per certain distance
Density of infrastructure for the pedestrians: m^2 or length of pedestrians streets or woonerven in the under study area.

Timesaver Standards for Landscape Architecture (Harris and Dines, 1988) includes a chapter on desirable lighting levels for pedestrian facilities, and specifies the following levels of illumination for sidewalks:

Table 3 Location of Lighting

Location of lighting		***Lux (lx)***	***Footcandles (fc)***
Sidewalks Along Roadsides:	Commercial areas	10	0.9
	Intermediate areas	6	0.6
	Residential areas	2	0.2
Sidewalks Distant From Roadsides:		5	0.5
Pedestrian Tunnels:		40	4.0

At this point it should be mentioned that the use of the results from different surveys should lead to the creation of threshold values for each country.

3.4 Transport system characteristics which determine the outcome of strategic decisions regarding walking (i.e. quality of road network, public transport system, distance to PT stops, traffic flow, comfort, speed, travel time, travel, transportation and traffic information)

3.4.1-4.2 The most important factors and the strength of this relationship

“*Transport system characteristics”* determine the outcome of strategic decisions regarding walking. At this point the transport characteristics which affect peoples’ decisions in terms of walking and how these characteristics can determine peoples’ behaviour according to walking are presented. Thus, some of these transport system characteristics are the following:

- **Quality of road network**: quality of roads for drivers and for pedestrians such as: pedestrianisation schemes, adequate pavements, pedestrian crossings, safety bars, information signs, etc., factors which characterized by ***comfort***, ***safety***, ***security***. As a result people will move safely and comfortably on the walking network. The walking environment will be friendlier. Only then the road network will attract new-old pedestrians who will move on road network safety without the fear of traffic. On the other hand, maybe high traffic (traffic jam) will turn people away from the use of private vehicles.
- **Quality of Public Transport System**: this means adequate bus stops distances, waiting times, travel times, frequencies of buses, reliability, safety, comfort, etc. For example, if the bus stops are far away from one’s home-work, then someone will not walk in order to reach the bus stop. He/she will prefer to use a private vehicle for reaching his/her destination. Public Transport plays an important role in walking decisions: if Public Transport System becomes more attractive, then more people will use their foot in order to reach bus-train stops.
- **Travel time-Travel speed**: if someone needs a lot of time to reach his/her destination by foot, and then he/she will prefer to use vehicles in order to reach his/her destination in time.
- **Traffic flow** cause fear to pedestrians especially to VRU (i.e. fear of not crossing the road in time).
- **Transport Information-Intelligent Transportation Systems** (signs, “smart” bus stops, telematics, etc).

3.4.3 Transport system characteristics which impede the pedestrians’ safe mobility

Bad quality of road network in terms of geometrical characteristics, signing, visibility, surface materials used, equipment etc.

- ***Mixed*** pedestrian trips – vehicular traffic (conflicts between pedestrians-vehicles).
- ***Inadequate infrastructure*** for the pedestrians (especially where trip demand exceeds infrastructure supply).

3.4.4 The relation of outcome with other factors and mechanisms

The outcome is related to many other factors and mechanisms such as:

- ***Guidelines*** for the design of a safe and comfort environment for the pedestrians (are there any?, level of implementation ?).
- Number and efficiency of ***respective authorities*** (adequate legislative framework, avoidance of overlapping activities etc.).
- ***Traffic education***.
- ***Age***, ***experience***, ***attitudes*** etc. of road users.

3.4.5 Threshold values with regard to go-no go decisions

- Severance effect.
- Changes on daily trips made by the pedestrians in cases they need to cross a major road characterised by heavy traffic volumes in the “after” situation (i.e. new roads, widening of existing roads).
- Density of crosswalks: number of crosswalks per certain distance.
- Density of infrastructure for the pedestrians: m^2 or length of pedestrians streets or woonerven in the under study area.
- Use the results from different surveys in order to have threshold values. Another possible outcome could have this form: $y=a_0 + a_1 x_1 + a_2x_2 + a_3 x_{3.....} + a_n x_{n.}$

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ITS and on-trip tasks while walking.

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"- Can someone please tell me which way I should go to get out of here?.
- That depends on where you wish to go –the cat-.
- I am not worried about where to go.
- Then it doesn't really matter which way you go –the cat-."
Lewis Carroll (Alice in Wonderland).

Summary

This chapter gives some examples on how Intelligent Transportation Systems (ITS) can help pedestrians with their on-trip tasks while walking. The chapter is based on a literature survey. The different uses and possibilities of the ITS for improving the mobility and safety of pedestrians in urban spaces is classified in 7 function types: for getting contact and/or being localised, for guidance (leading/navigating), for alerting or informing of a danger, for adapting the environment to pedestrian conditions, for promoting confidence and/or security, for counting and controlling flows, and for helping people with special needs. The most important developments are described with links to their websites in which one can gather more information.

1. Introduction.

The Consequences of inadequate traffic panning regarding pedestrians' needs leads to an unfriendly walking environment and people might be afraid to walk; this leads to the exclusion of vulnerable road users from activities in society. On the other hand, the reduction of walking has economic implications for society (i.e. less shopping) and individuals as well. In order to improve walking conditions for current pedestrians and to attract new ones, the walking environment should be improved. This means improvements on safety, security, aesthetics, traffic noise, emissions, severance effect and infrastructure provided for the facilitation of pedestrian trips.

From a road safety view, responsible authorities should provide a wide area for pedestrians' movements, segregated paths, safe location of paths, "to design and maintain paths to a high enough standard to attract the vulnerable road users away from the smooth road surface, ideally by providing a sealed surface”, and offering signs and information systems for the safest and more accessible walking trip (CaSE project, undated). In addition, a series of measures which were mentioned above in order to improve pedestrians’ safety and accessibility, and change their daily habits and the ways of their movement, should be taken into account. Therefore, the quality of mobility and safety to pedestrians and cyclists, whether they are walking or cycling for pleasure, to access services and facilities, to catch public transport, or walking to and from a car parking, must be a major focus of any road safety strategy or policy.

ITS seem to be needed to satisfy pedestrian and drivers’ quality needs. Intelligent signal-controlled crossings for pedestrians should automatically detect pedestrians, as well as prioritising and adapting green phases; especially child pedestrians need these features. Probably, in-car ITS is the most efficient measure to achieve a safe and independent freedom of movement for pedestrians. However, if a pedestrian or bicyclist is hit by a truck or bus, the fatality risk is high at any speed. Therefore, also ITS measures like ADAS, are needed to see and be seen and measures are needed to improve orientation and create clarity.

Information technology (IT) was defined by the Information Technology Association of America (ITAA) as: "the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware." IT deals with the use of electronic computers and computer software to convert, store, protect, process, transmit, and securely retrieve information.

The consideration of IT in the world of transportation originates in the development of that which is called “Intelligent Transportation Systems” (ITS) expression that refers to the application of information and communication technologies to the transport infrastructure and vehicles, in order to improve their efficiency and safety, and especially in the context of this paper to meet pedestrians’ quality needs.

The chapter is based on a literature survey. The most important developments are described with links to their websites in which one can gather more information. The studied ITS systems are related to the following different functional needs of pedestrians, (and in some cases needs of vehicle drivers to improve their interaction with pedestrians):

1. For getting contact and/or being localised
2. For guidance (leading or navigating)
3. For alerting or informing of a danger
4. For adapting the environment to pedestrian conditions
5. For promoting confidence and/or security (avoiding victimisation)
6. For counting and controlling flows
7. For helping people with special needs.

2. Scope of this paper

2.1. Aim

The aim with this chapter is to categorise recent experiences where ITS can improve pedestrians’ mobility and safety, and develop new ideas based on ITS to better meet pedestrians’ functional quality needs in the future.

2.2. Target groups

Target groups of this chapter are professionals working in the field of traffic planning; practitioners, planners and researchers.)

2.3. Delimitations

This paper covers ITS related to in-trip tasks. ITS related to pre-trip tasks, are excluded in this paper but is presented in sections B.1.7 and B.1.8. of this PQN Final Report.

3. ITS Application areas

3.1. For getting contact and/or being localised.

The developments that permit a person to establish contact from wherever one finds oneself with his/her family or aide and correspondence service would enter in this section, such as the other developments which permit one to be localized from a remote distance.

Among these developments, those framed by the term “emergency call systems”, type “eCall system” (Virtanen, Schirokoff and Luom, 2005), or the ordinary mobile phone in combination with special numbers pre-introduced and, in some cases, associated to determined key numbers (like *emergency number* and *“call centres”*), or special radiophones which people with handicaps or aged can carry with themselves (e.g.: hanging from a necklace).

Other projects such as the LOCOMOTION project would also fit here to provide wireless care for elderly and disabled people. Thanks to the combined use of GPS and standard mobile phones, this system puts the elderly and disabled in contact with their caretakers by means of extending alarm and contact systems to outside home. At the same time, caretakers can localize the users of this service at any moment.

In addition, new advantages of recent appliances are being discovered. For example, within the frame of project SIZE, *“Life quality of senior citizens in relation to mobility conditions”* (EU’s Fifth Framework Programme, 2003-2006), the importance of the ordinary mobile phone was shown to be a promoting factor in the mobility of older persons (Zakowska and Monterde-i-Bort, 2003; Monterde-i-Bort and Moreno-Ribas, 2003).

This importance of the ordinary mobile phone, as a factor which favours mobility, was studied in greater depth in a partial study specifically accomplished by the data collected in project SIZE (Moreno-Ribas and Monterde-i-Bort, 2005), and the statistical analysis revealed that the simple fact of carrying a phone with them (elderly people) was a determining factor in deciding to leave the house (for a walk).

This study came to three conclusions:

1) Firstly, the discovery of the role of the ordinary mobile telephone as an enhancing factor for the mobility and autonomy of senior citizens (in Europe). Concerning this result and looking further into it, it is important to highlight that the single and simple circumstance of having an ordinary mobile phone may be a sufficient condition for going out of doors.
2) Secondly, this circumstance, that senior citizens could have mobile phones with them, has not received the attention level by politicians, technicians and decision makers which it seems to deserve as a telematics solution for enhancing and/or keeping the mobility, autonomy and independence, of our senior citizens. This solution was considered

3) And thirdly, this circumstance of having an ordinary mobile phone (the possibility of carrying it with them), appeared as an important predictor variable of the autonomy-independence of older adults, ahead of some variables related with public transport facilities, in this population group.

The importance of this new telematics device as a factor for enhancing or stimulating the mobility and autonomy of senior citizens has to lie in the fact that the mobile phone gives to older adults security to go out of doors. The security is offered by the possibility of making contact with the family, health centres or help services whenever they want it.

In line with these results we can also cite simultaneous studies that analyze the new “roles” of the mobile phone (from the simple idea of “something you can carry with you”), in which we can support ourselves to extend these conclusions to all groups of the population, not just older adults (Ito, 2005; Ito and Okabe, 2003).

Consequently, the “ordinary” and “simple” mobile telephone has to be included within the group of telematics devices and as a part of ITS used to ensure safe transport and, specially in this case, as an arousing factor for going around and walking.

3.2. For guidance (leading or navigating)

The category of systems of navigation developed specifically for walking would enter in this section and include mobility of this sort as an option.

For this function we can distinguish two large groups of devices: those based in GPS and those not based on GPS, the latter are normally used to complement to the first in order to improve their accuracy getting a seamless positioning.

a) <u>Within the first group (GPS-based) we can find systems like</u>:

- The **“Easy Walk”**, developed by Vodafone, is and innovative system of navigation based on the GPS system and in Symbian mobile phone technology. It offers blind or visually impaired persons information of their actual position (localisation), and also permits them access to assistance and useful information in order that they can move in an extremely easy and independent way. The use of this technology can also extend to non-handicapped persons.

- The **Telmap Navigator**. This instrument combines the GPS and the mobile phone, and by means of special software, supposedly capable of guiding the pedestrian to the extent of the best route possible, using pedestrian footpaths with clearly detailed maps which show places and companies, and also labels and references in streets. Telmap Navigator provides maps with zoom. Once in the desired zone, one can easily find the places and businesses on the map, and details like the address and phone number – one can even call directly from the Telmap Navigator.

- The **Nokia mobile phones with navigation service**. Nokia has been pioneering in personal navigation mobile phones, by including to some phone models three basic functions: navigation, position and travel distance, lately also with options specially for walking.

- The **Mobile Navigator 7**, software developed by NAVIGON for PDA’s and mobile phones working under Symbian operative system. This version incorporates the specific needs for pedestrians. Including a compass that indicates the direction to your destination as the crow flies, plus the distance exact to the metre. The walking direction, so even if users deviate from the planned route users will never lose sight of where they are or need to go. In addition, the software will actively prioritise the use of small lanes, narrow paths and pedestrian-only routes.

- **Tele-Atlas pedestrian maps**. This company specialized in developing maps for GPS devices, is developing versions of maps specific for pedestrians. This way, Tele Atlas combines its traditional Multinet cartographic database with a series of special attributes for citizens on foot, which eases the outline of specific routes and providing facts of interest, which will permit pedestrians to orient themselves in unknown areas and move about freely through more adequate paths. Moreover, these maps identify the place in which a pedestrian is situated at any moment. This way, the new digital cartography, that contains detailed information about tunnels, foot-bridges or pedestrian paths, will provide security and comfort for persons walking about, improving the act of walking the streets and facilitating the traveller with the shortest pathways to his/her hotel or the closest metro station, or facilitating to the executive person, the suitable route to reach the meeting spot from the parking lot. Likewise, this database, valid for users of portable navigation devices and mobile phones, offers a range of points of interest specifically for pedestrians, such as the location of restaurants, businesses, or ATMs, evading unnecessary paths and permitting them to save time in their displacements.

b) Within the second group (non-GPS based systems), we can distinguish again between two sub-types: systems based in the use of radio-beacons, and systems based in algorithms which estimate the movement of a person from different data supplied for their own movement.

b1) We count systems based on the use of radio-beacons for guiding pedestrians, on those solutions which use Radio Frequency Identification (RFID) tags or transponders. A RFID tag is an electronic circuit which can be incorporated into a place, product, animal or person for the purpose of identification and tracking using radio waves. The potentials for use are very wide in industry, and in the field of pedestrians they can be used for navigation purposes (to guide someone to go from one point to other, to develop safety or optimal paths in the cities, to help blind people or, even, for paying bus tickets without doing nothing). An example of application in this context could be the experiment developed by Daito’s team (Daito et al., 2004).

A newest evolution in this field consists in the introduction of the Bluetooth communication technology in development of radio-beacons. So, the Talking Points project developed in the University of Michigan (2008), which combines Internet, Bluetooth and a portable communication device (like the mobile phone) would be a representative example. This project, in the words of its developers, can be seen as the first step in the direction of the audio-virtual reality designed for blind people and also very practical for the sighted community. The project is based on the situation of radio-beacons (Bluetooth-beacons) at urban points if interest (public toilettes, bus stops, restaurants with menu in Braille,…), which emit Web contents and those with which the user can interact by means of a portable device (like mobile phone), by tactile or audio means, to solicit more information. This possibility of interaction by means of vocal commands is constitutes a novelty in comparison with other similar systems.

The main difference of these systems with satellite based system is that the radio-beacons does not need digital mapping, since they provide the symbol of the signal and the information about their position by themselves. The radio-beacons are also useful to complement satellite position systems in places with reception difficulty (tunnels, indoors) and with handicapped people (blinds, visual impaired).

b2) Among the second sub-type of systems, based on estimation algorithms of displacement of a pedestrian from the data produced by his/her own movement, normally beginning with a first position signal acquired from another system (GPS, RFID,…), we can mention the MEMS Based Pedestrian Navigation System.

The MEMS, acronym of micro-electrical mechanical system, based pedestrian navigation system (PNS) for seamless positioning consists of a biaxial accelerometer and a biaxial magnetic compass mounted on a shoe in conjunction with a batch of computer algorithms developed for estimating characteristics of displacement and position using a neural network whose inputs are the walking information. (Cho and Park, 2006).

Finally, in this subhead about solutions for guidance, it is necessary to mention some resources which are not devices properly, but they are resources for guidance which either also belong to the ITS field or can improve the existing ITS devices, even be a component of them. We select two as representative examples: the service “get directions: to here from here”, with “by walking” option, offered by Google-Maps through Internet, and the attempts for developing urban routes based on “Landmarks” (Landmarks-based Pedestrian Navigation Systems) (Millonig and Schechtner, 2005).

3.3. For alerting or informing of a danger

Below systems that detect the presence of pedestrians and alert or inform them of the risks in the way, or also those warning of the presence of pedestrians to the other users of the road (drivers) are described.

The developments in this field are principally directed at avoiding automobile-pedestrian and automobile-cyclist collisions (accidents). We can distinguish two kinds depending on whether the detector is mobile (that goes in the vehicle) or fixed.

a) Among the systems based in the synchronization of portable devices (GPS in a car and a mobile phone for a pedestrian), we emphasize the system developed by OKI called DRSC (Dedicated Short Range Communications) which advises the driver and the pedestrian when the proximity of both devices indicates danger of contact, and the development of the automobile factory NISSAN, which advises the driver, by means of the GPS device installed in the car, of the presence of pedestrians in the risk space.
b) And among the systems based in the installation of fixed devices (generally in pedestrian paths) we highlight the following projects: the PICS project (Development of Pedestrian Information and Communication Systems) (Yachi, Ohkubo and Takeuchi, 1999; Aotani et al., 2001) which by means of installation of infrared emitter in intersections or pedestrian crossings, one is advised of the existence or proximity of persons with visual limitations (Blind people, handicapped, older adults,…), who carry a portable device capable of reception (PDA, mobile phone); and the Spanish project MEPP (Mejora de la Percepción de los Peatones en los Pasos de Cebra – Improvement of Pedestrian Perception in Pedestrian Crossings***)*** (González and De la Peña, 2008) which by means of installation of devices that detect the presence of pedestrians the drivers who come are alerted by means of special signals. (More information and an application experience in: http://www.aecarretera.com/DOCUMENTO_TECNICO_RESUMEN.pdf).

Concerning the devices used both to detect and alert, we can mention, besides the RFID systems already commented above, the following: microwave, ultrasonic and infrared detectors (to detect presence), count-down signals (to inform pedestrians about time remaining), in-pavement lights (to alert drivers for pedestrian crossings), illuminated pushbuttons (immediate feedback to pedestrians about ordering reception), animated eyes display (to alert pedestrians looking direction), signal-mounted speakers, and the group of subsystems considered under the expression *"Accessible Pedestrian Signals"* (APS), which include several systems to provide "walk/don't walk" information (Hughes et al., 1999; 2001), using one or any combination of the following ways: tones, speech messages, vibrating surfaces and/or messages to receiver hardware (pedhead-mounted, pushbutton-integrated, vibrotactile-only and receiver-based).

An inventory of these solutions and tests of their application is carried out in the PedSmart project (US Department of Transportation, 2000; Ulster County Transportation Council, 2007), a website (www.walkinginfo.org/pedsmart) developed by the University of North Carolina Highway Safety Research Centre for the USA Federal Highway Administration, with the objective of describing the technologies in use and providing links to manufacturers and other resources.

"Automatic pedestrian detection at Intersections" and *"Variable (or Changeable or Dynamic) Message Signs (VMS/CMS/DMS)"* are the main research lines in this field.

3.4. For adapting the environment to pedestrian conditions

Below solutions and devices are described which are mounted in the street pavement or furniture, (cross-walks, pedestrian paths,…), and have as main objective to modify the environment for adapting it to the presence and characteristics of the displacement of pedestrians (elongation or expanding of the green light time, sequence of exchange of traffic lights, forcing reduce speed, etc).

Many of these devices need some of the mentioned devices in the earlier section first *to detect* the presence and the characteristics of the displacement of pedestrians, without having to do something special (passive detection), and also of other devices (ultrasonic, Doppler radar, video Imaging, piezometric pressure sensors,…). This group of detectors is referred as "Passive Pedestrian Detection". But, unlike those other uses, to alert is not their main purpose.

This kind of solutions can be directed both to driver, to force a speed reduction (for example), as to infrastructure, to adapt it to the particular characteristics of each pedestrian.

a) The solutions for this purpose directed to act on drivers are those *"Intelligent Speed Adaption (ISA)"* measures which could be used for setting the car speed to the characteristics of pedestrian presence.

b) Among the solutions for this purpose directed to act on infrastructure we can put as example two developments applied on crossings: PUFFIN (Pedestrian User Friendly Intelligent Signals) and PUSSYCAT (Pedestrian Urban Safety System and Comfort at Traffic Signals) (Beckwith and Hunter-Zaworski, 1998; Davies, 1992; London Dept. of Transport, 1993; Tan and Zegeer, 1995). And the DRIVE II project VRU-TOO (Vulnerable Road User Traffic Observation and Optimization) system (Carsten, Sherbone and Rothengatter, 1998; Sherborne and Hodson, 1995). The influence of these solutions on pedestrian crossings are: replacing the normal push-buttons, providing earlier activation of the pedestrian stage, providing an extension of the pedestrian stage for late arrivals, and providing longer pedestrian stages when there are larger number of detections or the pedestrian displacement is lower than the normally estimated (older adults, impaired,…).

Next ITS examples with response to pedestrians are presented. Figures 1 and 2 present a pedestrian traffic signal and sign correspondingly, where the pedestrian read the light message or look the sign before crossing the road.

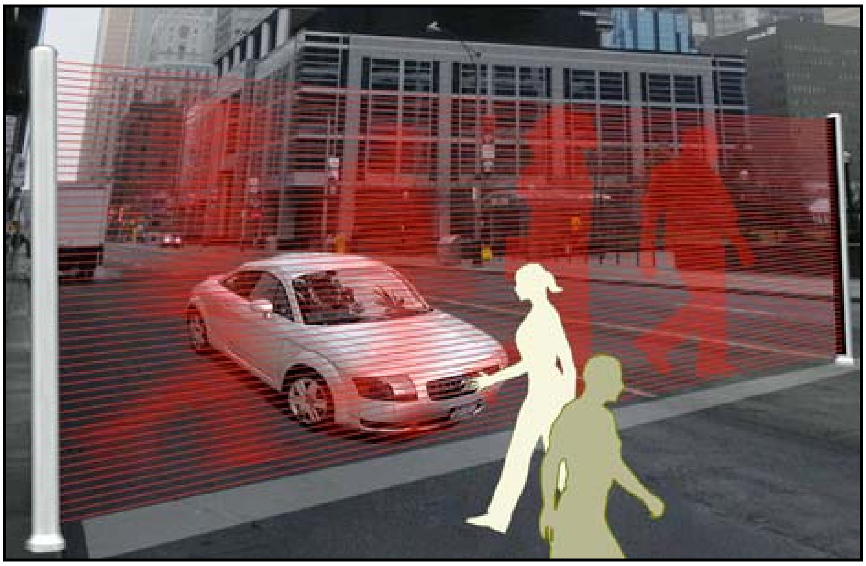
Figure 1 Pedestrian signal.

Figure 2 Pedestrian sign.

(Photographs taken from www.flickr.com)

Another, futuristic example is presented in Figures 3, 4 and 5. They show different aspects of the original idea of the Virtual Wall designed by Lee Han Young to protect pedestrians in pedestrian crossings (Espinoza, 2008; HanYoung, 2008; Murph, 2008): "The Virtual Wall provides a barrier made up of plasma laser beams depicting pedestrians doing what they do best and any car that crosses that barrier suffers the consequences. Maybe those lasers aren't powerful enough to do any harm but the effect is enough to make drivers and pedestrians alike follow crosswalk rules to the tee". (HanYoung, 2008).

Figure 3 Crosswalk protected by a virtual wall (HanYoung, 2008)



Figures 4 The HanYoung's Virtual Wall from pedestrian perspective (HanYoung, 2008)

Toshiba has been conducting research and development of a system that can provide various types of information to pedestrians. Among the features of the system that it has developed is a voice interface. Input data is made by a voice recognition method and information output by a voice synthesis method. This system can handle not only Japanese, but other languages as well such as English and Spanish.

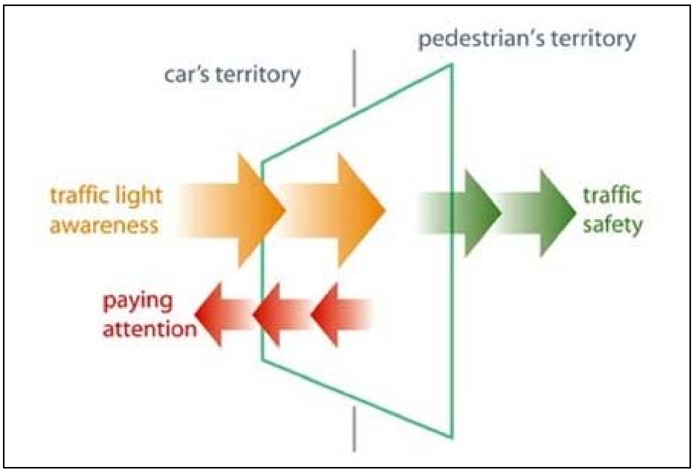


Figure 5 The HanYoung's idea of fund (HanYoung, 2008)

3.5. For promoting confidence and/or security (avoiding victimisation)

Devices such as cameras and emergency-call push-buttons/phones in streets, parks, stations, metro/ train carriages, elevators/lifts, etc., where the presence of pedestrians is expected, are special purpose ITS, because besides of personal security for pedestrians should be guaranteed, the fear to be assaulted –victimisation- was one of the limiting factors for leaving home and walking revealed by the results of the SIZE research project (Zakowska and Monterde-Bort, 2003; Monterde-Bort and Moreno-Ribas, 2003; SIZE Consortium, 2003-2006).

3.6. For counting and controlling flows

This is another field for ITS application to the pedestrian world. Many devices for detection of presence described above, are also used for counting the flow of pedestrians, studying their decisions and preferences of displacement and for estimating the demands for capacity in different zones and on different streets. Also, to know the capacity for evacuation (in case of emergency) in public places that are closed in or semi closed in.

Urbix Technologies is a company specialized in all kind of pedestrian counter systems, with integral solutions like SMARTCOUNT service, and its website (www.urbix.com.ar) is a good exhibition of the possibilities of the different applications for different needs related to displacement of people.

3.7. For helping pedestrians with special needs

Telematics and other types of Intelligent Transportation Systems, ITS, such as Intelligent Route Guidance Systems (for pedestrians), Advanced Driver Assistance Systems (ADAS), Intelligent pedestrian crossings and Intelligent Speed Adaption (ISA) seem to be needed to satisfy Child Pedestrian and drivers' Quality needs.

Probably, Intelligent Speed Adaption on motor vehicles is the most efficient measure to achieve a safe and independent freedom of movement for children, Vehicle speeds should be 15-20 km/h or less wherever children 7-12 years old (regularly) cross streets. For older children the same principles apply as for adult unprotected road users: they should not cross at locations where vehicle speeds exceed 30 km/h. Pre-school children should not encounter cars in their playing and walking areas. However, if a pedestrian or bicyclist is hit by a truck or bus, the fatality risk is high at any speed. Therefore, also ITS measures like ADAS, are needed for children to see and be seen and measures are needed to improve orientation and create clarity.

Advanced Driver Assistance Systems' (ADAS) or other Assistance Systems for bus drivers, which detect approaching children, are promising technical aids for drivers. To increase schoolchildren's safety, school bus drivers can activate a signal to stop motor traffic before the bus comes to a bus stop. Within the framework of the IN_SAFETY project, a corresponding intelligent system has been tested and patented in the USA. The school bus sends out signals when it is about to stop to activate a warning signal in approaching vehicles equipped with ADAS. Additionally, Anund, Kronqvist, and Falkmer (2005) recommend that the sign on school buses should be supplemented with a flashing light placed nearby. An intelligent bus has been developed to make school transport safer. The bus has additional equipment, including external loudspeakers, internal and external monitoring cameras, seatbelt reminders, belt cushions, and additional internal and external mirrors. The children are given microchips, and the driver receives information as to which children are to get on or off at a bus stop, as well as having the ability to communicate with and watch children both inside and outside the bus. A warning system at stopping places alerts other road users to the presence of children on the road (SAFEWAY2SCHOOL).

Mobile telephones can be equipped with intelligent signposting systems to recommend the safest route, and also to allow parents to keep track of children (see eg. TomTom).

Intelligent signal-controlled crossings for pedestrians should automatically detect pedestrians, as well as prioritising and adapting green phases. As an alternative or supplement to pedestrian pushbuttons, highly placed microwave or infrared sensors are used to detect pedestrians automatically. Intelligent systems have also been developed for marked non-signalized pedestrian crossings (see e.g. Jarlebridge AB's home page, 2007).

Most of the solutions and devices developed for guidance have mainly been developed to compensate the limitations of handicapped or impaired people, like the Talking-Points project already described above (additional information can be found in http://talking-points.org/).

Another new development in the field of the IT is the implantable and/or portable devices. This line of recent research in science and engineering is focused in development of a new class of electronic devices based in biomedical technologies to be implanted or attached to the own body in order to influence on the perceptual-motor system. These devices are characterised by size (micro-devices), a new wave of wireless, low power and hermetic functioning.

Within this new developing line, we should mention the BMES Program (Biomimetic MicroElectronic Systems) developed by the University of Southern California in the Engineering Research Center (http://bmes.erc.usc.edu , http://bmes-erc.usc.edu/industry/ , http://www.erc-assoc.org/factsheets/15/15-Fact%20Sheet%20Save%20as%20Webpage.htm). And others initiatives like the BION Devices (Injectable Interfaces with Peripheral Nerves and Muscles), based in implanting electrical stimulators in the body to compensate clinical disorders (http://www.medscape.com/viewarticle/542356_6).

4. Requirements of the ITS installation

The requirements of ITS operation are:

- Involvement of the Public into the decision process - Public acceptance
- Adequate funding
- Availability of technology & infrastructure
- Know-how & past experience (if any)
- Support from legislation.

5. Recommendations

Final target is an improvement of the walking environment by means of ITS in order to increase the possibility for pedestrians to walk in a safe and secure manner.

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Parameters determining route choice of pedestrians in walkable networks.

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'Anywhere is walking distance,
if you've got the time.'
Stephen Wright, American writer

Summary

The focus of this chapter is the modelling of a decision process that takes place on the tactical level of a pedestrian's trip. The tactical level is defined in delimitation to the superior strategic level and subordinated operational level with respect to trip purpose and spatial relations. Whereas on the strategic level the purpose, the origin and destination, the choices for traffic mode and time of departure are being set before the trip starts, on the tactical level, decisions are being made for the actual route or diversions within the pedestrian's network during the trip.

At the tactical level, the decision making process can be modelled by the minimisation of walking costs in a network that takes into account both the network related quality and individual related factors. In this chapter, the concept of pedestrian quality attributes and its evaluation by physical assessable factors are introduced.

In order to enable the application of the model, it is assumed that in principle experiences are gained by the walking pedestrian from prior knowledge of the walking network. This is the essential precondition for the decision making process that is based on a conventional route search algorithm. Instead the routing decisions by pedestrians are drawn in a mental process during walking that can undoubtedly be characterised as non-formalistic.

The purpose of the formalistic approach described in this chapter is to help understand the influencing factors and mechanisms of the decision making process as it is intended in the process of analysis of pedestrian quality needs.

1. Introduction

For the analysis and modelling of decision processes, a spatial model of a walkable network is introduced. This walkable network model is utilised for the valuation of network related pedestrian quality as the basis for tactical routing decisions including individual human factors. The pedestrian quality is attributed to network elements according to a concept of virtual distances as the result of the valuation process.

The decisions for route choices are being made under assumptions of utility maximisation of the individual pedestrian. In that way the utility maximisation follows the principles of finding the shortest paths by a virtual distance attributed network and thus incorporates the valuation of network related pedestrian quality.

Although microscopic models of pedestrian behaviour on the operational level are not regarded in this chapter, there still exist various contact points and interrelations between the tactical and operational levels. The operational level refers to pedestrian behaviour on sidewalks between two decision points. But also for unrestricted walking on squares or large places, routing decisions and behavioural aspects intertwine and will be considered. For these cases references to relating chapters will be indicated for a more detailed discussion.

2. Model of a walkable network

2.1. Definition of nodes and links

A walkable network is regarded as a directed graph consisting of nodes and links characterised by topological connectivity, attributes and geographic features, as illustrated in Figure 1.

A node of the walkable network is defined at each point where a pedestrian can make a decision for his travel direction, typically intersections of sidewalks along roads, partings of ways and also places, squares or similar. On the tactical level also a place of some spatial extent, like a market place, is regarded as one node of the network.

A link of the walkable network refers to a traffic connection from node to node that can be traversed by pedestrians usually in both directions. The direction of the link often refers to the direction of its construction, i.e. the digitising process or a predefined direction like chaining the road documentation. Knowledge about the link direction is important for the reference of direction dependent attributes of network elements, for example differing pedestrian qualities on each travel direction.

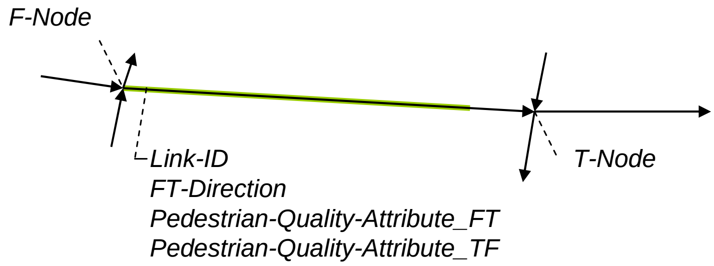


Figure 1 Elements of a walkable network model with pedestrian quality attributes *PQA*

Typical examples of links in a walkable network besides sidewalks are also greenways in parks or footpaths in gardens, way-leaves through buildings, passage-ways, pedestrian bridges or underpasses that are important traffic connections. It is evident that urban pedestrian networks are generally more complex than the underlying road network that can be referenced by a digital street map.

Topological connectivity as a precondition for routing refers to the model of the walkable network in order to enable a search for a path through the network. In theory, for a pedestrian it is usually possible to use any connecting link from any given network node for routing unless its use is restricted by fences or barriers which is modelled by a table of forbidden turns.

2.2. Sources for models of pedestrian networks

A number of sources can be utilised to create a model of the walkable network for a selected area in a city. Commercial providers of digital road maps make their products available in various formats for further processing in a Geographic Information System (GIS) or spatial databases. Digital road maps contain both the geometry and useful attributes for each link in the network. The licences for use must be purchased and may be restricted to dedicated application cases.

The OpenStreetMap project is a free editable map which is continuously extended and supplemented by a community of users using GPS tracking data. Regarding the circumstances that this work is voluntary, the degree of completeness and level of detail of the map is remarkable, as shown in Figure 2. Geometric data of line objects representing streets and paths can be exported into XML-format for further processing without the need of licensing.

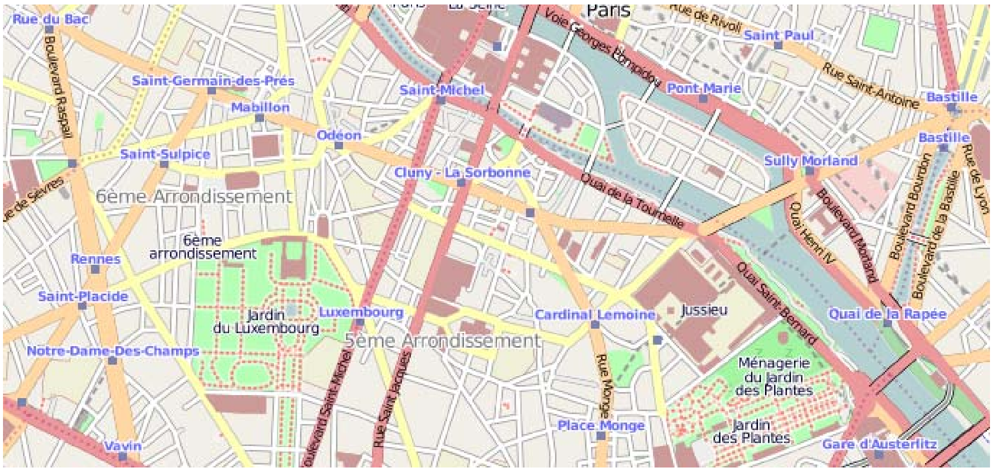


Figure 2 OpenStreetMap section of central Paris

Additional sources of geometries and link attributes are road databases, street information databases and pavement management systems operated and administered by municipal authorities.

Regardless of the various sources of information, a unified database structure is necessary to represent the walkable network of the concerned area. General requirements for this structure include geometries, bidirectional link attributes and topological connectivity.

2.3. Places for stay and sojourn

Any place in a walkable network that has an increased amenity value or quality of sojourn should be considered as a so called Point of Interest (POI). From the network point of view these places constitute a node, even if this place is located along a link that has no additional connected links to this node.

In the network model such POI, like a sight or an attractive resting place usually can be considered as a destination of the current trip and logically as another origin for the next trip. Even if the interruption of the trip is only for a short time, with respect to the relation between origin and destination it is assumed that the POI is considered as a fixed waypoint that is not altered during the trip.

Hence, it can be assumed that a place with increased sojourn quality is not relevant for a routing decision during the walk on the *tactical* level. Because it is not an intermediate node on the trip it is also not a decision point for a routing decision. A decision point is consequently defined as any node that connects at least two links that lead to alternative routes to the same destination. A route is accordingly regarded as a consecutive sequence of connected links.

The attraction effect of improved sojourn quality places will be taken into account at the *strategic* level on which trip planning for source, destination and waypoints is performed, be it intentionally or subconsciously. In Figure 3 this essential difference in the relationship between route decision and fixed waypoint is illustrated. From origin to first decision point marked in black no alternative route is available. Routing decisions lead to several alternative routes for walking in a park area that is marked green. Although various paths lead to the destination, the POI is a waypoint on the route to be visited purposefully, so it is outside the network part in which decisions are taken.

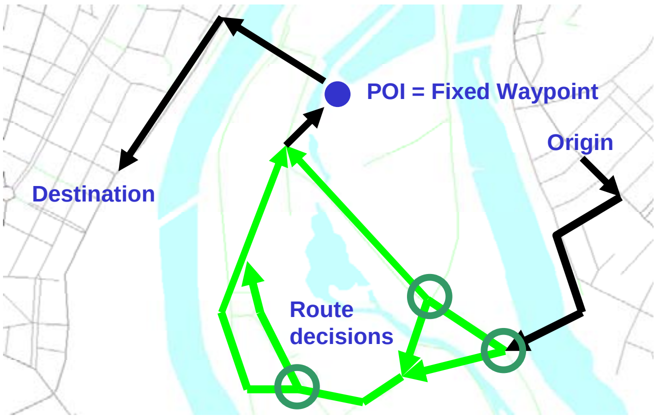


Figure 3 POI as fixed waypoint vs. variable route decision points

2.3. Walking zones and freely navigable areas

The node/link model for a pedestrian network can not be applied within areas of considerable extent like market places, pedestrian zones or town squares. As the movement of individuals in these areas are relatively unrestricted with respect to direction, location of direction change, interference with other pedestrians, attractive and repulsive forces etc., the modelling approach for this typical *operational* walking behaviour requires a higher degree of freedom in two dimensional motion.

A solution to this theoretical problem was proposed by Helbing and Molnár, (1995) through the introduction of the *Social force model*. It was suggested that the movement of pedestrians can be described as if they would be subject to 'social forces'. These forces are not directly exerted by the pedestrians' personal environment, but they are a measure for the internal motivations of the individuals.

The nonlinearly coupled LANGEVIN equations of this model include a term describing the acceleration towards the desired velocity of motion, terms reflecting a pedestrians' intention to keep a certain distance to other pedestrians and borders and finally a term modelling the attraction effects.

This microscopic model was implemented in the simulation software *PedWalk,* a multi-agent rule based behavioural simulation package included as part of *BotWorld, see* Bruse (2002). The problems of pedestrian behaviour like motion in freely navigable areas, evasive manoeuvres, group forming and lane formation reside at the operational level and will be discussed in relating chapters. In connection with the evaluation of individual pedestrian related factors concerning route choice on the tactical level, only the social interaction is considered later in this chapter.

3. Valuation of network related pedestrian quality

The evaluation of a walkable network includes the quantification of quality factors according to the method explained in this chapter. The physical measurable data of street planning and construction such as sidewalk width may be collected through GIS and road infrastructure databases operated by local authorities. The majority of factors need to be assessed in the field through audits supported by evaluation checklists.

3.1. Introduction of the Pedestrian Quality Attribute

The valuation of the network elements with respect to pedestrian quality aims to provide a methodology to quantify physical prevalent factors by either measurement or estimation in the field or through planning documentation.

For valuation of pedestrian quality the term quality attribute q_P is introduced. The quality attribute is the weighed sum of quality sub-attributes in the categories safety q_S, accessibility q_{Ac}, attractiveness q_{At} and comfort q_C.

The Pedestrian Quality Attribute *PQA* is given by

$$PQA = q_P = a_S q_S + a_{Ac} q_{Ac} + a_{At} q_{At} + a_C q_C \tag{4-1}$$

with

$$0 < a_S, a_{Ac}, a_{At}, a_C < 1 \text{ and } -1 < q_P, q_S, q_{Ac}, q_{At}, q_C < 1 \tag{4-2}$$

where the domain of q_P ranges from poor (-1) to excellent (1).

Each of the quality sub-attributes are weighed by the corresponding weighing coefficients a_S, a_{Ac}, a_{At} and a_C. For each quality category a defined number of quality factors contribute to the total quality that is to be assigned for each link in both travel directions.

For example the quality category q_S is given by

$$q_S = \frac{1}{n}\sum_{i=1}^{n} q_S[i] \tag{4-3}$$

with quality factors $q_S[i]$. In this chapter only two factors will be examined in detail for each category. However the proposed method is suited for any amount of data that is available in a field study to be of use for the evaluation process.

3.2. Physical assessable factors

Amongst the great variety of physical factors influencing and determining pedestrian quality, the most important have been selected from the author's point of view to demonstrate the proposed method of evaluation of network elements. For each of the categories, safety, accessibility, attractiveness and comfort are analysed in more detail. Their suitability for physical quantification and the degree of impact within an aggregate quality attribute is documented.

3.2.1. Quality category - Safety

In this category two quality factors are examined further, safety of crossing facilities and motor traffic volumes and speed. As the importance of this category is assumed to be greater than for the categories of comfort and attractiveness it will be rated higher by 10 percent overvaluation. This amounts to a weighing coefficient of a_S =0,275.

3.2.1.1. Quality factor - Safe crossing facilities

Signalised intersections and traffic light controlled crossing facilities for pedestrians (pelican crossings) are important contributions for improved safety in the traffic network. Especially for pedestrians as vulnerable road users, a safe crossing with motorised traffic is indispensable. Therefore the existence of safe crossing facilities along a road segment constitutes the most important quality factor in this category.

The minimum distance of mid-block crosswalks, pedestrian refuge islands or pelican crossings can be defined as 300 m in between. If this distance is exceeded on a link, there is an raised risk that school children will not obey the safe crossing. Therefore any additional distance to the next pelican crossing or crosswalk reduces the safety and pedestrian quality.

Let d_{Cr} denote the distance between crossing facilities, then the quality factor $q_{S,Cr}$ can be determined with

$$q_{S,Cr} = f(d_{Cr}) \qquad (4\text{-}4)$$

where the function $f(d_{Cr})$ is qualified by the graph shown in Figure 4.

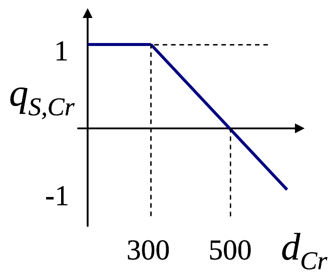


Figure 4 Relationship between distance of crossing facilities and corresponding quality factor $q_{S,Cr}$

If the measured crossing distance is higher than 500 m, the quality factor will fall into the negative (repulsive) range.

3.2.1.2. Quality factor - Motor traffic volumes and speed

High volumes of speeding motor traffic impose a major deterioration of pedestrian quality on sidewalks situated along arterial roads. This relates especially to the safety aspects of pedestrians crossing the street in mid-block situations, but also to possible danger that occurs as cars may slide onto sidewalks or truck loads fall off endangering vulnerable road users.

The influence of speed onto quality is incorporated through parallel characteristic curves representing typical speed limits at urban streets shown in Figure 5.

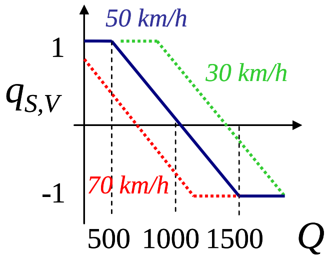


Figure 5 Relationship between motor traffic volumes and speed and corresponding quality factor $q_{S,V}$

Let *Q* denote the volume of traffic flow in vehicles per hour measured on a lane, then the quality factor $q_{S,V}$ can be determined with

$$q_{S,V} = f(Q,v) \tag{4-5}$$

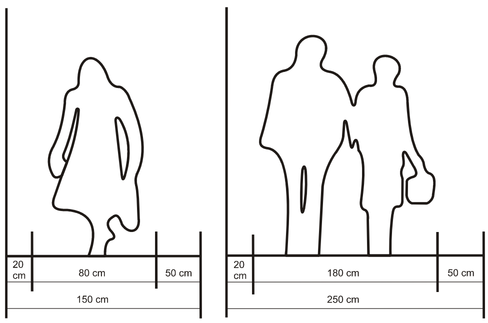
where the functional relationship *f(Q,v)* is represented by the graph shown in Figure 5. The graph qualifies the relationship between the maximum speed limit as well as the measured traffic flow volumes and the corresponding quality factor.

3.2.2. Quality category - Accessibility

In this category two quality factors will be examined further, sufficient width of sidewalks and steepness of slopes. As the importance of this category is assumed to be greater than for the categories of comfort and attractiveness it will be rated higher by 10 percent overvaluation. This amounts to a weighing coefficient of a_{Ac} =0,275.

3.2.2.1. Quality factor - Sufficient width of sidewalks

The most significant factor related to the criteria of accessibility is an adequate supply of sidewalk width depending on the demand of pedestrian traffic. For the planning and construction of sidewalks, technical guidelines exist that define the minimum requirements and necessary additions for safety clearance distances to buildings, roads, shop windows, trees, bicycle stands etc. Figure 6 illustrates the minimum case of necessary sidewalk width to provide the entry level of pedestrian quality.



Measure	Distance
Clearance to building	20 cm
Room for one person	80 cm
Room for two persons	180 cm
Clearance to road curb	50 cm
Total (for 2 persons)	250 cm

Figure 6 Minimum requirements for sidewalk width

In order to assess the factorial quality of width as part of the total quality, the existing width of a link must be measured. The quotient of existing width divided by planned minimum width for the link is called the width ratio *w*. The width ratio relates to the quality factor $q_{S,W}$ according to the linear relationship shown in Figure 7.

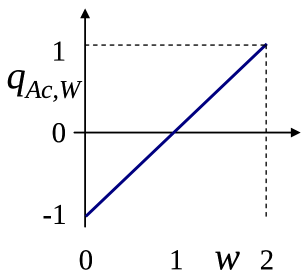


Figure 7 Relationship between width ratio and corresponding quality factor $q_{Ac,W}$

If the measured sidewalk width is lower than the minimum width, the quality factor will be in the negative (repulsive) range.

3.2.2.2. Quality factor - Steepness of slopes

The steepness of slopes accounts for the most important quality factor related to accessibility of public space. Especially for impeded pedestrians or even persons using wheelchairs the steepness of a slope is an important factor for route planning and decision making. Slopes of up to 25% or 14° inclination can be surmounted by healthy pedestrians, but would impose a barrier for disabled persons. For wheelchairs a maximum steepness of 6% is suggested in Germany. The valuation of the quality factor depends on the direction of travel. In an upward direction the quality is diminished, whereas in a downward way it is not affected, see Figure 8.

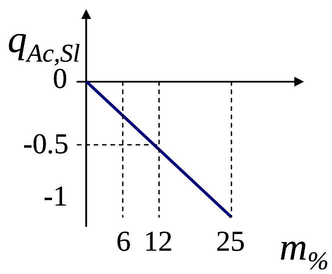


Figure 8 Relationship between steepness in percent and quality factor $q_{Ac,Sl}$

3.2.3. Quality category - Attractiveness

For the quality category of attractiveness, the factors maintenance of open space and lighting are considered. According to a 10% lower evaluation for this category the weighing coefficient is assigned to a_{At} =0,225.

3.2.3.1. Quality factor - Maintenance of open space

For the assessment of public space maintenance, the main aspects include quality of pavement and green areas, appropriate urban furniture, availability of public toilets, etc. Many additional aspects may be identified that can improve or worsen the general impression of a public area or pedestrian facility. Because of this variety, the assessment of quality is achieved by applying a grade system that refers to this general impression.

Maintenance grade	Assessment	Quality factor $q_{At,M}$
Excellent condition	A	1
Good condition	B	0.5
Satisfactory condition	C	0
Poor condition	D	-0.5
Unacceptable condition	F	-1

Figure 9 Grades for assessment of maintenance of public space

The table shown in Figure 9 provides an allocation of grades with respect to a linguistic assessment of maintenance condition of public spaces and their attribution to quality factor $q_{At,M}$. Any interpolations between grades are viable and lead to respective adjustments of the quality factor.

3.2.3.2. Quality factor - Lighting

The illuminance is a photometric measure of the luminous flux per unit area of light. Illuminance at the surface of a pavement is the normative technical measure for the perceived brightness. A spatially evenness of illuminance on the pavement is important for the recognition of obstacles, persons and vehicles. The SI unit for illuminance is lux (lx) or lumen per square metre (lm/m^2) and can be measured with a lux meter. For pedestrian facilities located along streets or in parks and residential neighbourhoods, the minimum requirements for illuminance are defined in national standards, as shown in Figure 10.

Facility - Area	Illuminance in lx
Urban pedestrian zone	5
Urban market places and squares	5
at temporarily high pedestrian traffic volume	10
Greenways in parks	1
Crosswalks	3
Stairways inside	100
outside	15
Arcades and passages	15
Underground crossing	50-100

Figure 10 Illuminance requirements for urban pedestrian facilities in Germany

For the assessment of the factorial quality of sufficient illuminance of a given network segment as part of the total quality, the present value must be measured at the surface of the pavement. The quotient of measured illuminance divided by required minimum illuminance for the examined link is called the illuminance ratio *i*. The illuminance ratio *i* relates to the quality factor $q_{At,L}$ according to the linear relationship presented in Figure 11.

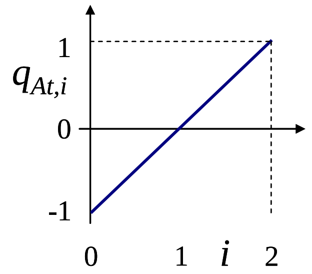


Figure 11 Relationship between illuminance ratio and corresponding quality factor $q_{At,L}$

3.2.4. Quality category - Comfort

The quality category of comfort includes two quality factors, noise level mainly of motorised traffic and vegetation and cast of shadow. The importance of this category is assumed to be lower than for the categories of safety and accessibility. Therefore the corresponding weighing coefficient is set to a_C =0,225.

3.2.4.1. Quality factor - Noise level

The noise level induced from individual motorised traffic correlates with speed and volume of cars and heavy trucks. Higher noise levels along sidewalks of arterial roads will most likely lower the comfort level and quality of the referring pedestrian facility. In the case of available alternative routes the chances are high that a routing decision will follow a more comfortable way as long as all other factors and the distances are equal.

Noise as unwanted sound is measured physically in decibels as sound pressure level (A), where the A denotes a filter that attempts to adjust sound measurements to correspond to loudness as perceived by the average human. Some examples of sound pressure are given in the table below.

Source of sound	Sound pressure level in dB (A)
Leaves rustling	10
Calm room	30
Talking person	50
Car at 10 m distance	60-80
Arterial road at 10 m distance	80-90
Jack hammer at 1 m distance	100
Pain threshold	130

Figure 12 Examples of sound pressure

Sound pressure level can be directly measured by an instrument such as a sound level meter over a defined period of time. In direct measurement the value as logarithmic measure in dB is displayed at the meter. For evaluation of the measured average values, a functional relationship is given in Figure 13. In the example displayed, a measured sound level of 70 dB(A) will result in a reduction of quality factor $q_{C,N}$ by 50 percent.

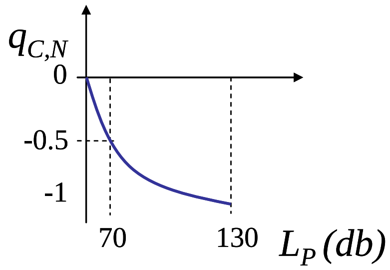


Figure 13 Noise level quality factor $q_{C,N}$ as a function of average sound pressure

The non-linear relationship is justified under the circumstances that raising sound pressure levels that are likely to occur along urban roads will lead to a substantial aggravation of pedestrian quality.

3.2.4.1. Quality factor - Vegetation and shadow cast

The lack of vegetation or manmade shadow casting structures is a quality reducing factor especially in southern countries during summer times. The ratio of shadowed area in relation to the total area of the considered pedestrian facility is used as a physical measure to determine the degree of shadow cast. For the sake of simplicity it is assumed that sunlight radiates vertically onto the surface.

The total area of a pedestrian facility such as a sidewalk is determined by the product of sidewalk width and length of the considered traffic network link. The shadow area for trees can be approximated through the diameter of the crowns added by shadow areas cast by manmade structures. The ratio of shadowed area to total area is denoted as A_{Sh}.

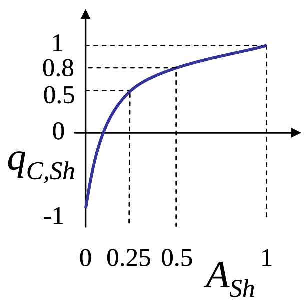


Figure 14 Comfort factor for vegetation and shadow $q_{C,sh}$ as a function of shadow area ratio

The functional relationship given in Figure 14 characterises the dependency of quality factor for vegetation and shadow cast as a nonlinear curve. In the examples it is shown that a shadowed area of 25% would result in a quality factor of 0.5, i.e. this would add an attractive momentum to the calculation of the total pedestrian quality attribute of the referring traffic link.

3.2.5. Evaluation example

For the evaluation of pedestrian quality, a sidewalk along an urban road section close to a tourist location in the city of Magdeburg, Germany serves as an example. The street is named *Breiter Weg*, the evaluated section extends from *The Cathedral* to *The Green Citadel (Hundertwasserhaus)* with a total length of about 320 m.

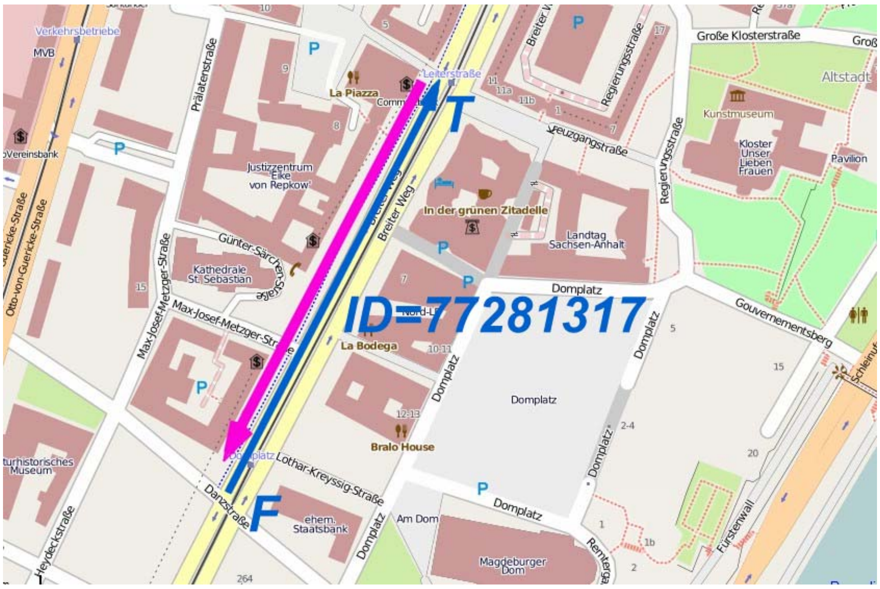


Figure 15 Evaluated sidewalk on west side of *Breiter Weg,* Magdeburg, Germany

In reference to the NavTeQ street map this road section is identified by ID=77281317. The evaluation is carried out for the westerly situated sidewalk. The reference direction is determined by the driving direction for right hand traffic which is indicated by the magenta arrow in Figure 15. However, the corresponding NavTeQ link (blue arrow) is oriented in the opposite direction. Hence, the value of quality attribute *PQA* to be determined must be assigned to the field *PQA_TF* of a database table that refers to the digital street map.

Quality category	**Quality factor**	**Physical value**	**Quality symbol**	**Value**	**Mean**	**Weigh factor**	**PQA**
Safety	Crossing facilites	285 m	$q_{S,Cr}$	1	0,85	0,275	0,234
	Traffic volumes	1000 @ 30 km/h	$q_{S,V}$	0,7			
Accessibility	Width of sidewalk	10 m	$q_{Ac,W}$	1	0,5	0,275	0,138
	Steepness of slopes	0%	$q_{Ac,Sl}$	0			
Attractiveness	Maintenance of space	A	$q_{At,M}$	1	1	0,225	0,225
	Lighting	10 lx	$q_{At,L}$	1			
Comfort	Noise level	70 dB(A)	$q_{C,N}$	-0,5	-0,75	0,225	-0,169
	Vegetation/Shadow	< 10%	$q_{C,Sh}$	-1			
						Total	0,428

Figure 16 Calculation of the Pedestrian Quality Attribute PQA for the given direction

Thus, an evaluation for the pedestrian quality of the westerly sidewalk consists of the determination of quality factors of the equation

$$PQA\_TF = q_P = a_S q_S + a_{Ac} q_{Ac} + a_{At} q_{At} + a_C q_C \quad (4\text{-}6)$$

As a result of quantification of physically measured values, each quality factor is determined using the functional relationships given. The quality factors are averaged for each quality category, weighed and summarised as the value of the total pedestrian quality for the given direction. The table in Figure 16 summarises the calculations for the evaluated example. The total PQA results in the positive value of 0,428 which is to be interpreted as an explicitly attractive momentum that will lead to a preference of this section in the route planning process.

3.3. Soft factors and social forces

Besides physical assessable quality factors, also various soft factors or social forces can lead to either attracting or repelling pedestrians to parts of the network and influencing their routing decisions. These factors have in common that prior knowledge must be available to the individual pedestrian about their kind and location. If these soft factors exist temporarily, an influence on a routing decision can only be assumed if it is visible to the individual at the point of decision.

Examples for attractions are possibilities of social interaction like groups of persons, street artists, street markets and temporary exhibitions or street festivals. Examples for repelling factors are socially insecure places like known crime spots and areas known for loitering and beggary, as well as alcohol and drug abuse.

The valuation of soft factors, as an increase or decrease of the quality attribute *PQA,* can be realised by estimating the social force factor a_{SF} for each concerned network element.

The domain of a_{SF} is defined as

$$-1 < a_{SF} < 1 \quad (4\text{-}7)$$

valued from repulsion (-1) to attraction (1). The social force factor is added to the evaluated link related pedestrian quality attribute *PQA*. As such, the social force factor serves as an additive measure for the further increase or decrease of the virtual distance between nodes of the network.

$$WA = \frac{1}{2}(PQA + a_{SF}) \quad (4\text{-}8)$$

The resulting attribute is denoted as walkability attribute *WA* and measures the cost for travelling the network paths. Decisions for route choice are drawn during the routing process that determines the shortest virtual path.

3.4. The walkability attribute as a measure of virtual distance

As mentioned in the preceding section, the pedestrian quality attribute is determined by evaluating the walkable network by means of quality factors. Hard quality factors are directly measurable whereas soft quality factors are assessable by estimations. As a result of the evaluation process, there are two values obtained for *PQA*, each one for both directions of the link. The quality attribute, if the impact of soft factors is also included, will be denoted as walkability attribute *WA*. The walkability attribute is utilised to define a measure for the virtual distance that is essential for a routing decision that takes into account the link quality and social factors.

The basic idea is to include the pedestrian quality into the routing decision with the concept that poor quality, i.e. a low attribute value will increase the "felt" distance for the pedestrian. An increased "felt" distance, further denoted as virtual distance, will lower the chances of a link to be chosen at a decision point if an alternative way exists, that features at least the same virtual distance. Otherwise, this virtual distance decreases at a positive quality assessment of the link that is more attractive. In the process of utility maximisation which is presumed as a basis for the routing decision, always the shortest virtual distance will be chosen by the pedestrian.

4. Valuation of individual pedestrian related factors

Apart from quality related factors there are important human factors that will have a strong impact on routing decisions on the tactical level. The trip purpose, personal fitness as well as time constraints will have a significant influence on route choice.

However, on the tactical level these influences are regarded to be constant, since it is not expected that these factors will change during a trip. Hence the individual factors are considered as additional input quantities for the utility maximisation process of route choice that will influence the decisions evenly over the entire network.

The human factors are therefore subject to considerations at the strategic level, but the kind and dimension of impact on the tactical level will be examined in the following section.

4.1. The individual trip purpose

The purpose of a trip has a major influence on the way of taking individual on-trip routing decisions. Within the model discussed so far, pedestrian quality is related to the network only. Therefore, the individual factor of the trip purpose determines to which extent the quality of the network will be taken into account when the routing decision is being made. Two scenarios from the perspective of the commuter (the impatient traveller) and the tourist (the patient traveller) act as examples to consider the main differences with respect to route choice.

4.1.1. Commuter trip to work place with time constraints - The impatient traveller

For a commuter trip under the time constraint of a scheduled arrival time it is assumed that an individual pedestrian will take the most effective route from home to the workplace, or in a multimodal trip from public traffic stop to destination. This case can also be characterised by an *impatient* traveller in a hurry to an appointment. In general, the chosen route in this case is the shortest path between the starting point and the end point throughout the pedestrian network.

As such, the physical distance of network links is the exclusive basis for route choice of the commuter. Hence, it is used the geographical length of network links as routing attribute *RA*.

$$RA := length(network\_links) \tag{4-9}$$

The exact route could be found through a routing algorithm using the physical distance as a measure to weigh the travelling costs to be minimised. In practice, the pedestrian will carry out the route planning in a similar way, although this is accomplished without calculating the exact distances.

By using a map, the human being is intuitively able to determine the shortest path between two given points in a network through alignment of the planned path as close as possible to the straight connection. This is performed through mental abilities in the process of visual assessment and evaluation without the need for exact calculations.

4.1.2. Leisure walking without time constraints - The patient traveller
For the trip purpose of a leisure walk or stroll, or any trip done by a patient traveller without any strict time constraints, the quality aspect is assumed to be most important. This case can be modelled by applying the walkability attribute *WA* as the exclusive measure to weigh the travelling costs for minimisation by the route search.

$$RA := -WA(network\_links) \qquad (4\text{-}10)$$

A pedestrian route in a quality weighed network is optimal if the travelling costs over the network links are minimal. Since positive values of *WA* represent an increased quality they must be inverted for use as a routing attribute that is to be minimised.

The travelling costs for each link are determined using the valuation procedure for the network related pedestrian quality described above. Therefore a route search algorithm using the walkability attribute would find a different route than the shortest physical distance between origin and destination.

The route choice of an individual pedestrian would rely on the same preconditions that are valid for a routing algorithm under the circumstances of quality preference. For the route choice at the tactical level, a prior knowledge of the individual about the network quality is essential.

4.2. Personal fitness and moods

4.3.1 Gender
From the perspective of *pedestrian quality* it is assumed that no gender specific factors have an impact on route choices during the trip. While en-route, the male or female pedestrian has already gained knowledge about the quality of the pedestrian network from earlier walks. Although gender specific differences exist with respect to acquisition of knowledge about the quality of the pedestrian network, it is assumed that the reasoning that leads to a decision for a certain route among existing alternatives is not gender specific.

In a recent published study on gender differences in use of cues for route navigation (De Goede, 2009), it was revealed that males and females differ in their reliance on cues during route learning. While females tend to rely more on landmarks that are situated along a route, males are apt to use geographical cues like direction and distances. These interesting results raise more possible research questions to proof or fail the assumption if there were *no* gender specific factors on route choice during a trip while travelling within an already known network.

4.3.2. Age
The age of a pedestrian is not a specific category to be considered with respect to route choice as long as physical abilities are equal among different aged user groups. A higher number of aged pedestrians may have less time constraints during a trip although this can not be generalised. A trip with young children will have a reduced range but the rules for route choice remain the same where adults are concerned as long as physical abilities allow.

Also physical abilities differ broadly within user classes ordered by age. The individual personal fitness is the main factor to be considered when distinguishing between a pedestrian's route choice that depends on their capabilities for instance to overcome steep slopes or stairs.

4.3.3. Personal abilities

Personal physical abilities or disabilities have the most impact on route choice in a pedestrian network. If an element of the network contains a barrier or hurdle that can not be surmounted by persons with a certain degree of disability, not only this network segment is affected but also every route that may lead over the affected link. Thus, the routing decision is influenced for the referring link as well as for adjacent preceding or following link elements possibly for a definite part of the network.

In relation to the described model of an attributed pedestrian network that contains the introduced attribute *PQA,* the personal ability can lead to an altered routing decision due to separate evaluation of the quality category accessibility. Given a certain degree of disability that prevents a pedestrian to surmount slopes steeper than 12%, a routing decision needs to be taken that avoids any of the affected network links that meet the given restriction either completely or at least in the ascending direction. By evaluation of the referring category it is possible to generate special routes that meet diversified requirements for disabled persons.

In a simpler implementation, a network could also be attributed with an additional binary value that indicates any restricted accessibility as FALSE that will block this link for any further routing enquiry. An application of this principle is shown in Figure 17. A pedestrian navigation application has been developed at the University of Maryland that includes information on accessibility of network elements. In order to find an accessible route throughout the pedestrian network of the University Campus, the user is enabled to select features that are included in the route search. Impaired users of the routing aide system can choose to avoid stairs or use sloped curbs as well as avoid steep inclines. The routing enquiry is processed considering attributes of the network and preferences of the user and his personal abilities.

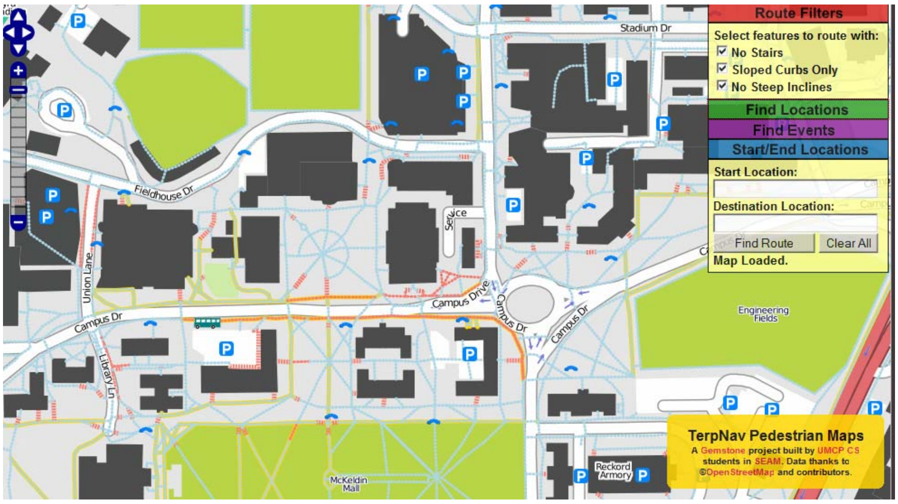


Figure 17 Pedestrian routing considering accessibility information
Source: TerpNav- http://map.umd.edu/map/

5. Pedestrian's route choice - a maximisation of utility

In the preceding sections it was analysed under which circumstances pedestrians choose their route in a walkable network from origin to an intended destination under the assumption of previously acquired knowledge about the network. The common assumption that pedestrians normally choose the shortest available route was extended by the introduction of the Pedestrian Quality Attribute *PQA* as a measure of virtual distance in the attributed network that incorporates the pedestrian quality as part of the walking cost.

5.1. Trade-off between distance and quality

The pedestrian like every human is subject to utility maximisation. The utility for the pedestrian takes into account two dimensions. The first dimension is related to an efficient consumption of energy that is necessary to travel a distance between two points in a network. This dimension of utility is responsible for the tendency to minimise spatial distance, i.e. to find the shortest path between origin and destination.

The second dimension is related to the aspect of pleasure. The more the pedestrian quality prevails, the higher grade of pleasure is achieved. A friendly walking environment can gain the same level of an overall utility if the spatial distance is greater compared to a shorter path with a lower level of quality. The natural trade-off lies in the substitution between the two goods of pleasure and energy savings. In Figure 18 this problem is illustrated.

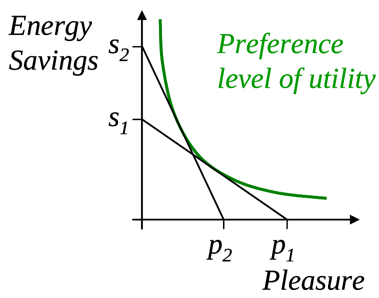


Figure 18 Substitution of Energy Savings and Pleasure

The relationship between both goods can be described by a Cobb-Douglas utility function on the two-dimensional form of

$$u(s, p) = s^{\alpha} p^{\beta} \tag{4-11}$$

with goods *s* representing distance and *p* representing quality and $\alpha\beta$ as output elasticities of the goods *s* and *p*.

In economics, the Cobb-Douglas functional form of utility or production functions is widely used to represent the relationship of an output to more than one input. In the two dimensional figure, a view on top of the three-dimensional Cobb-Douglas function is shown that indicates a fixed level of equal utility as a convex indifference curve (green).

An optimal decision is characterised by the budget constraint lines that intersect the utility level in one point. Thus, an increase in walking pleasure because of a better pedestrian quality must lead to a decrease in energy savings, i.e. higher energy consumption because of a longer distance (p_1-s_1). Alternatively an increase in energy savings due to route choice of a shorter but low quality route leads to a decrease in pleasant walking conditions (p_2-s_2).

Which budget constraint line is being chosen by the pedestrian depends on the prevailing situation, individual preferences, the trip purpose and the personal fitness. A commuter trip to a work place, as discussed above, would be characterised by the budget constraint line p_2-s_2, a leisure trip would be indicated accordingly by p_1-s_1.

5.2. Attribution of walking costs

Since all route search algorithms depend on an attributed network to determine the optimal route under the given preferences, the appropriate selection or combination of attributes is essential for the intended use case to be modelled. As already discussed above, it is necessary to use the spatial distance to attribute the network in order to model the case of a commuter trip.

The virtual distance as a measure of walking costs was introduced to take into account the pedestrian quality and human factors into the concept of routing. This virtual distance is related to a link as a network element which can enlarge or reduce the "felt" physical distance depending on the decrease or increase of quality. Concerning quantification of the virtual distance it is required that the attribute value must be positive, since any route search algorithms solve the shortest path problem only for networks with nonnegative path costs.

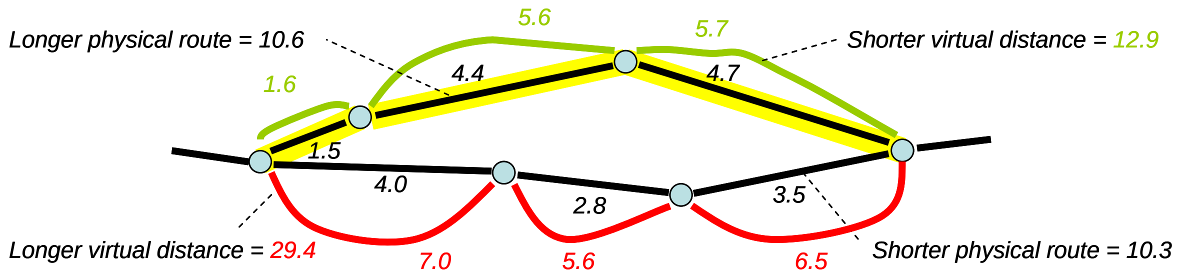


Figure 19 Route choice based on virtual distances

The example of Figure 19 illustrates the case of using the virtual distance instead of the physical distances. The shorter physical route between two alternative paths has a length of 10.3. The longer physical route has a length of 10.6. By including quality aspects the (red) virtual distance of the short route is 29.4, whereas the longer route has a (green) virtual distance of 12.9. Assume for the pedestrian the maximisation of utility under no time constraint, then the quality is more important than the route shortness. Therefore the shorter virtual attributes will be used for the route search that will finally yield to the (yellow) route.

5.3. Minimisation of costs through route search

In order to be able to use the discussed mathematical model of analysing parameters of route choice, it is necessary to emphasise that an individual pedestrian needs to acquire prior knowledge about the quality of the network along the route towards his destination and about possible existing alternatives as a precondition for making decisions on route choice. In the presented considerations it is assumed that a pedestrian is informed about the network quality from experiences of earlier walks.

Under these circumstances the route search at the tactical level can be carried out by a graph search algorithm that solves the shortest path problem in the cost attributed network. The application Dijkstra's (1959) algorithm and other extended or derived algorithms such as A* or Bellman (1958) – Ford (1962) deliver the solution according to specified premises.

The necessary preconditions for the application of the route search model are defined as follows:

1. Origin and Destination as start and end nodes of the considered pedestrian network are known and set.
2. Alternatives of more than one route from origin to destination exist in the network.
3. The network quality is evaluated and attributed to any affected link in both directions.
4. The individual factors as trip purpose and user abilities are defined.

After the definition of preconditions, the routing decisions are found by the following steps:

1. Given the attributed network, the virtual distance is calculated as a function Pedestrian Quality Attribute *PQA*.
2. Given the virtual distance of each network link and the spatial distances, the total walking costs are assigned whether using the virtual distance or the spatial distance depending on individual preferences such as time constraints and abilities.
3. Given the total walking costs, the route is determined as a result of the utility maximisation by minimising the costs over all paths through any path finding algorithm such as the Dijkstra algorithm.

The routing decisions result from the calculated route and are related to the given attributed network under defined preconditions and assumptions.

6. Conclusion

At the tactical level, the decision making process can be modelled by minimising the problem of walking costs that take into account both the network related quality and individual related factors.

Experience of the walking individual gained from prior knowledge of the walking network is the essential precondition for the decision making process. The routing decisions are drawn during walking in a mental process that is undoubtedly non-formalistic.

The purpose of the formalistic approach described above is to help understand the influence factors and mechanisms of the decision making process as it is intended in the PQN project.

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Functional abilities of humans and identification of specific groups.

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Summary

This chapter discusses the abilities of humans, particularly those of the most substantial groups of pedestrians. The chapter is divided into three parts.

The first part is about the abilities of humans manifested when they walk and which are necessary for a safe movement of all pedestrians. Abilities or characteristics of humans are divided into four main groups and consist of the physical (body), psychomotor, sensory and cognitive (mental) abilities.

The second part of the chapter analyzes groups of pedestrians formed based on their abilities, and includes children, adults, older people and people with disabilities. At the end of this subsection, some groups categorized as “others” are mentioned, as they are being analyzed with increased interest. In the second chapter, bearing in mind the features/barriers connected to an each separate group of pedestrians, we have analyzed the preconditions for the safe movement of pedestrians, related to the physical environment, social environment and accessibility to other forms of transport (transportation access). The second part of the chapter also deals with the characteristics that separate groups of pedestrians show when making decisions on a strategic, tactical and operational level.

The conclusion generally deals with recommendations and the importance of knowledge of various abilities/characteristics of different groups of pedestrians. This way, we can allow pedestrian movement as a model of transport to become the choice for all (C4A).

1. Introduction

The accepted definition of pedestrians in the “Pedestrian Quality Needs” project is: any person who walks or spends time in public space, without any special requirements related to special forms of walking is a pedestrian, for example, people who run, or enjoy the areas outside urban areas, such as mountaineers. This includes children whose toy is a form of transportation and people with disabilities who use various forms of moving aids (sticks, crutches, wheelchairs or scooters with 3 or 4 wheels). People who use scooters, stilts, Segways or other forms of transport means for fun are not in the category of pedestrians.

Pedestrians are a diverse group of participants in traffic, and this reflects the general characteristics of the population. When shaping the environment and the places where different forms of transport meet with the pedestrian infrastructure, it is necessary to keep the pedestrians with different degree of ability in mind, as a basic principle of design, whenever possible. This approach will enable the removal of barriers and creating a pleasant, appropriate environment for all pedestrians.

The special approach in design, guided by a consciousness of the diversity of users, is indicated by the term “Design for All” (D4A). Design for All has roots in the Scandinavian functionalism since the `50s and ergonomic design from the `60s of the 20th century. The socio-political background of the concept Design for All was recognized in the Scandinavian social policy, which produced the concept of "Society for All" in the late `60s. This ideological belief is transformed into the United Nations Standard Rules on the equalization of opportunities for persons with disabilities, accepted by the UN General Assembly in December 1993. Focus on the standard rules of accessibility with a clear concept of equality inspired the development of the philosophy of design for all, which became the generally accepted concept in EIDD[1]. (European Institute for Design and Disability, 2004).

According to the Stockholm Declaration[2], the contemporary period is the time in which disease, injury and disability exist in everyday life like never before. Although the contemporary world is a complex place - it is still ours – and that is why we have the opportunity, and the responsibility to design based on principles of inclusion.

> ***Design for All is a design for human diversity, social inclusion and equality.*** *This holistic and innovative approach constitutes a creative and ethical challenge for all planners, designers, entrepreneurs, administrators and political leaders.*
>
> *Design for All aims for enabling all people to have equal opportunities to participate in every aspect of the society. To achieve this, the environment built, everyday objects, services, culture and information – in short, everything that is designed and made by people to be used by people – must be accessible, convenient for everyone in society to use and responsive to evolving human diversity.*
>
> *The practice of Design for All makes conscious use of the analysis of human needs and aspirations and requires the involvement of end users at every stage in the design process.*
>
> *The European Institute for Design and Disability therefore calls on the European institutions, national, regional and local governments and professionals, businesses and social participants to take all appropriate measures for implementing the “Design for All” in their policies and actions.* (European Institute for Design and Disability, 2004)

Considering the diversity of pedestrians, design production includes a wide range of user needs, including needs of children, persons with movement difficulties, and the elderly. All over the world, statistics indicate that the population is ageing. This means that there is an increase of people over 65 years of age.

To understand the approach, the problem of the different abilities of pedestrians in the next chapter will identify different groups of pedestrians and discuss their characteristics and needs. Based on the characteristics observed and needs of different groups of pedestrians, the following work discusses the system established around the pedestrian (physical environment, social environment and transport system) and the specific influence on abstract levels of decision making (strategic, tactical and operational).

2. Physical, psychomotor, sensory and cognitive abilities concerning walking

The very nature of a human determines the characteristics of its movement. When it comes to pedestrian movement, two characteristics in particular stand out: the provision of views in the direction of movement and paths of movement.

[1] EIDD – European Institute for Design and Disability
[2] European Institute for Design nad Disability. *The EIDD Stockholm Declaration.* Stockholm, 9 May 2004.

One of the most important characteristics of pedestrians is to look towards the goal they are moving to. For that, the width of view extends 15 ° to the horizontal line of sight. Turning to the specified line view happens when we let other phenomenon attract our attention. Small changes in the nature and height of surface area at which we move will not be perceived in most cases. However, when someone looks in the direction of a surface when moving, he or she might not perceive the problems that are possible to encounter. The reason for not perceiving changes in the area at which we move might be colour, texture, weak lighting, flash, etc.

Another characteristic is that pedestrians will move to a specific destination in most cases opt for the path whose overcoming spends the least energy. These paths are the shortest and have at least an oscillation in height. Due to their own nature, pedestrians tend to cross the street at the most appropriate place instead of the one where there is a pedestrian crossing.

According to research conducted by AASHTO[3] during 2001, pedestrians do not cross the distance of more than 1600 m (1 mile) to their job, or 800m (0.5 mile) to the transportation stop. The survey also showed that 80% of the length of pedestrian movement is less than 800 m (0.5 mile).

During the process of design of an effective pedestrian environment, we must follow the principle that adjusts various users. However, reality shows large differences among individuals in relation to the speed of motion, endurance limits, physical strength, physical performance, capacity assessment, which challenges the long accepted concept of “the average pedestrian”.

The definition of abilities would be that: they are individual characteristics that make someone perform certain actions and they can be divided into four groups: physical, psychomotor, sensory and cognitive abilities.

– **Physical abilities** are those individual skills that include strength, endurance, flexibility, balance and coordination.
– **Psychomotor abilities** are skills that affect the ability to manipulate and control objects.
– **Sensory abilities** are abilities that affect the visual, sound and speech perception.
– **Cognitive abilities** are the abilities that affect the acquisition and use of knowledge during solving certain problems.

Walking, crossing the street and involvement in traffic are complex processes that require adequate functioning and performance, so any impairment of cognitive or executive functions can be difficult due to poor walking, spotting incoming vehicles and the difficulties in crossing the street fast enough. (Oxley, Charlton, & Fildes, 2005) These factors increase the risk of traffic accidents.

According to their abilities, pedestrians differ widely. The difference in children’s height and cognitive abilities is equally important to be considered as well as decrease in the speed of reflexes, and hearing and visual quality of the elderly. Ability can also vary during a pedestrian travel, if we take into account that the pedestrian becomes tired or interfered with other actions carried out during the movement (if someone is accompanied by children, carrying luggage, and consumption of food, beverages or cigarettes during the movement, use of mobile phone, etc.).

[3] American Association of State Highway and Transportation Officials

Characteristics of pedestrians include the individual characteristics that are necessary to perform certain actions that involve pedestrian movement and influence each other's distinction.

Bearing in mind the specific characteristics and abilities of humans we can identify different groups of pedestrians (Table 1). Different groups of pedestrians are identified based on those characteristics that are necessary for the performance of pedestrian movement, according to the established definition of a pedestrian. The table shows the characteristics and abilities of pedestrians that influence pedestrian movement, and segments and elements of pedestrian traffic and infrastructure on which it can be reflected.

Based on abilities and characteristic mentioned above, we will describe individual groups of pedestrians that can be found, and their general characteristics and subgroups that can be recognised within isolated groups.

3. Functional preconditions for safe mobility and consequences of limitations and functional impairments

This subsection discusses the preconditions for safe mobility of pedestrians in relation to the physical and social environment and accessibility to other forms of transport. Also, it considers the consequences of limitations and functional impairments according to the structure of pedestrian decisions making defined by John Michon (Michon, 1979). In the first part, general preconditions are stated for the safe movement of pedestrians in relation to mentioned factors. Then, we talk about the character of different levels of decision making which include strategic, tactical and operational level. In the next subsection we will show the results of the analysis of different groups of pedestrians according to the mentioned topics: children, adults, elderly and persons with disabilities.

3. 1. Functional preconditions for (acceptable) safe mobility with respect to physical and social environment and transportation access

Functional preconditions for the safe mobility of pedestrians will depend on different factors physical and social, as well as climatic, environmental, technological, and so on. Here we will focus on physical and social environment and transportation access and try to expose them independently, but given that they are still interrelated.

3.1.1. Physical environment

Physical environment includes the natural environment and the built environment. Depending on the weather and the quality of the environment built, pedestrians will be able to move safely. Safe environment for pedestrian movement requires a space in which the possibilities of any kind of injuries are reduced to a minimum (Bazik, 2006).

External conditions, behaviour and clothes affect the pedestrians' visibility in traffic. The key factor is the level of contrast between a pedestrian and their environment.

Environmental factors affect the visibility of pedestrians by other participants in traffic. Rain, snow, fog, shadows and glare reduce the range and visual acuity. The reductions in visibility of pedestrians affect the level of maintenance of cars. Dirty or damaged windshield on cars reduces visibility and increases the effect of flash.

There are so-called "visual shelters" in the traffic environment. Vehicles of large dimensions in the movement, like buses or trucks, block pedestrian and car views. Immovable structures, such as parked vehicles, vegetation, and traffic signal control box may have the same effect.

About half of the serious traffic accidents happen in conditions of darkness or poor lighting. During the night, it might be difficult to recognize pedestrians due to reduced clarity. All of the factors that affect clear visibility of pedestrians often become critical during low light or darkness.

General measures concerning functional preconditions for the safe movement of pedestrians in relation to the physical environment would be providing the quality of space for movement of pedestrians that will motivate people to walk. Without a precondition for secure walking, the walking will be reduced to the most necessary, if there is no other option for movement.

Based on the research literature, Pikora and his colleagues found a wide range of potential factors that can affect walking and cycling. (Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003) Systematization of conclusions singled out key themes, which are consistent with four features of the physical environment as indicated: functionality, security, aesthetics and destinations. They are presented in the Table 2.

Table 1 Physical environmental factors that can affect walking and cycling

PHYSICAL ENVIRONMENTAL FACTORS

FUNCTIONAL	SAFETY	AESTHETIC	DESTINATION
Direct route Gradient Intersection design Intersection distance Kerb type Other access points Path continuity Path design Path location Path maintenance Path surface Path width Street design Street type Street width Traffic control devices Traffic speed Traffic volume Type of path Vehicle parking	Crossing aids Crossing Lighting Verge width Surveillance	Cleanliness Sights Garden maintenance Parks Pollution Trees Architecture Street maintenance	Local facilities Parks Public transport Services Shops Vehicle parking facilities Bike parking facilities

↓

WALKING/CYCLING IN LOCAL NEIGHBOURHOOD

↓

INDIVIDUAL FACTORS

Motivation
Interest
Social/family support
Health status

Table 2 Groups of characteristics and abilities of humans related to walking, http://online.onetcentre.org/find/descriptor/browse/Abilities

Group of abilities/ characteristics	**Characteristics of pedestrians**		The impact on the ability	Reflecting on
Physical abilities/ characteristics	**Height**		The ability to look over the objects Visibility of the other	Sight line (Line views)
	Dynamic flexibility		The ability of rapid and re-moving, stretching, or flat-out provision of the body, arms and legs	Crossing time Travel duration Sidewalks quality
	Strength	**Explosive strength**	The ability of a person to use short bursts of muscle force to propel oneself (as in jumping or sprinting), or throw an object	
		Static strength	The ability to exert maximum muscle force to lift, push, pull, or carry objects	
		Trunk strength	The ability to use your abdominal and lower back muscles to support part of the body repeatedly or continuously over time without 'giving out' or fatiguing	
	Gross Body	**Coordination**	The ability of a person to coordinate the movement of their arms, legs, and torso synchronised when the body is in motion	Provision of steps and ramps Kerb height Gradient Types of pavement
		Equilibrium	The ability of a person to keep or regain body balance or stay upright when they get in an unstable position	
	Stamina		The ability to exert yourself physically over long periods without being winded or out of breath Distance between rests	Rest places Crossing time Travel distance Sidewalks quality
Psychomotor abilities/ characteristics	**Manual dexterity**		The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects.	Traffic signalization which is activated by pedestrians
	Reaction time		The ability to quickly respond (with the hand, finger, or foot) to a signal (sound, light, picture) when it appears	
	Speed of limb movement		The ability to quickly move the arms and legs	Crossing time Travel duration
Sensory abilities/ characteristics	**Hearing**	**Auditory attention**	The ability to focus on a single source of sound in the presence of other distracting sounds	The need to increase the number of visual signs Realizing the danger on the road
		Hearing sensitivity	The ability to detect or tell the differences between sounds that vary in pitch and loudness	
		Sound localization	The ability to tell the direction from which a sound originated	

	Vision	**Depth perception**	The ability to judge which of several objects is closer or farther away from you, or to judge the distance between you and an object.	Readability characters Realizing prominence and location of the crossing Realizing the danger on the road Tactile pavement Traffic estimates
		Far vision	The ability to see details at a distance	
		Glare sensitivity	The ability to see objects in the presence of glare or bright lighting	
		Near vision	The ability to see details at close range (within a few feet of the observer)	
		Night vision	The ability to see under low light conditions	
		Peripheral vision	The ability to see objects or movement of objects to one's side when the eyes are looking ahead	
	Visual colour discrimination		The ability to match or detect differences between colours, including shades of colour and brightness.	Readability of the street environment Consistency of legal measures Using symbols The possibility of crossings
	Tolerating unpleasant temperature and environment		Tendency towards sheltered conditions	Location and exposure pathways The need for shelter from the wind and rain
	Fear for own safety and security		Ability to use the entire path or a part of it	Lighting Supervision Lateral separation from traffic Pedestrian flow Density and speed of traffic
Cognitive abilities/ characteristics	**Memorization**		The ability to remember information such as words, numbers, pictures, and procedures	Readability of the street environment Consistency of legal measures Using symbols
	Problem sensitivity		The ability of a person to tell when something is wrong or likely to go wrong. It does not include solving the problem, only recognizing there is a problem	Realizing prominence and location of the crossing Realizing the danger on the road Tactile pavement Traffic estimates
	Selective attention		The ability to concentrate on a task over a period of time without being distracted	
	Spatial orientation		The ability to know your location in relation to the environment or to know where other objects are in relation to you	Readability of the street environment
	Written comprehension		The ability to read and understand information and ideas presented in writing.	Readability of the street environment Consistency of legal measures Using symbols

This research considers those factors according to the standard walking (walking for recreation and walking for transport). In addition, the characteristics vary depending on the group of pedestrians.

3.1.2. Social environment

Depending on the group that pedestrians belong to, the social environment will have different effects on safe movement. For children, this aspect is mainly manifested in the educational sense, because children need to possess certain norms of behaviour and be able to point out potential hazards that they need to be aware of when they are active participants in traffic. On the other hand, there are aspects of the social environment that are related to characteristics of social inclusion as a broader area. The society should be aware of the needs of all categories of pedestrians and create such an environment in which all social groups can be included.

The most important aspect of creating a social environment that will be primarily safe for the movement of pedestrians, is that there must be a social commitment and respect (through the legislative framework) of the hierarchy of participants in the traffic (Figure 1), where the pedestrian is placed first on the ladder (Commission for Architecture and the Built Environment, 2008).

Consider first	Pedestrians
↓	Cyclists
↓	Public transport users
↓	Specialist service vehicles (eg emergency service vehicles, waste)
Consider last	Other motor traffic

Figure 1 People first – the new hierarchy in street design (London Department for Transport, 2007)

This way, the main orientation is towards the respect for the principles of inclusive design (D4A), different demands and needs of the users of public open space are defined and respected and different demands and needs of various types of motor vehicles are summarized.

Through this kind of orientation, we can remove the barriers that might affect the inclusion of all categories of pedestrians in traffic, but also influence the responsible driving behaviour related to pedestrians and the respect of their needs. The Commission for Architecture and the Built Environment in the UK presented such an attitude and placed it on a discussion in which different social actors were involved.

3.1.3. Transportation access

Depending on the distance that is to be crossed for reaching various destinations and performing a certain planned activity, it is necessary to combine walking with other forms of transport. If we look at the hierarchy mentioned earlier and we keep in mind the characteristics and needs of different groups of pedestrians, we will see that the first next type of movement on the ladder is riding a bike, than use of public transport after that, with driving a private car at the very end.

Choosing the use of other forms of transport largely depends on the previously mentioned social attitudes and awareness towards the protection of the environment and the accessibility of other forms of transport. This primarily relates to the organization and existence of a network of bicycle paths or public transportation and their equitable distribution on the territory observed. At the same time, different impacts and conflicts that different forms of transport might have on each other at their crossing pathways, must also be taken into account.

Physical environment, social environment and transportation access, as preconditions for the safe mobility of pedestrians, will affect the decisions on all three strategic levels regarding the movement of a pedestrian. The reason for this is that the preconditions listed do not act independently, but as a system.

3.2. Consequences of limitations and functional impairments according to the decision making levels

Considering the decisions and behaviour, John Michon (Michon, 1979) presented the idea of participants making traffic decisions on three levels: strategic, tactical and operational.

Strategic decisions are made before someone becomes a participant in traffic. This is the time when people take decisions such as a choice *where to go* (destinations) and *which type of transport* they will use to reach the desired destination. Strategic decisions related to the action marked by the verb “go”. These decisions are related, consciously and implicitly to basic needs, which Maslow explained, and basic "dimensions" of subjective parameters or components that can be recognized at a generic level, on a Pizza-model (Methorst 2003). Freedom of choice to making decisions about whether to go or not go and modal choice depends on:

- Individual freedom of mobility (depending on the individual's health, his wealth or ability)
- the social context (including perception of collective needs, norms, values and rules)
- how the land is used and the physical characteristics of the environment (destination distribution, quality, environment, lack of barriers, weather conditions, lighting, etc.)
- the quality of the transportation system (the general transport characteristics, quality of public transportation)

Tactical decisions are made while participating in traffic, and they are related to the path of movement, intersections, speed, etc. Tactical decisions are related to the action that marked by the verb “travel”. This level of pedestrian needs is related to factors that are more concrete:

- Individual abilities and motives for travel
- features that are related to people and traffic environment
- type of path and characteristics of the environment (rain, heat, wet surfaces by which we move, etc.)
- for those who decide to use some other form of transportation: accessibility to other forms of transport they have chosen

Operational decisions are the reactions of other participants in traffic, the traffic situation and other forms of interaction with people and animals. In the case of pedestrians, operational decisions can be spelled by the verb “walk”. Operational decisions are the result of:

- Individual abilities and intentions
- conflicts between people and traffic in the environment
- characteristics of the environment (availability and quality of the pedestrian environment)
- for those who choose to use another mode of transport: the accessibility of these forms of transport

On these presented foundation is based the basic conceptual model of the project Pedestrian Quality Needs which is offered in the following Figure 2.

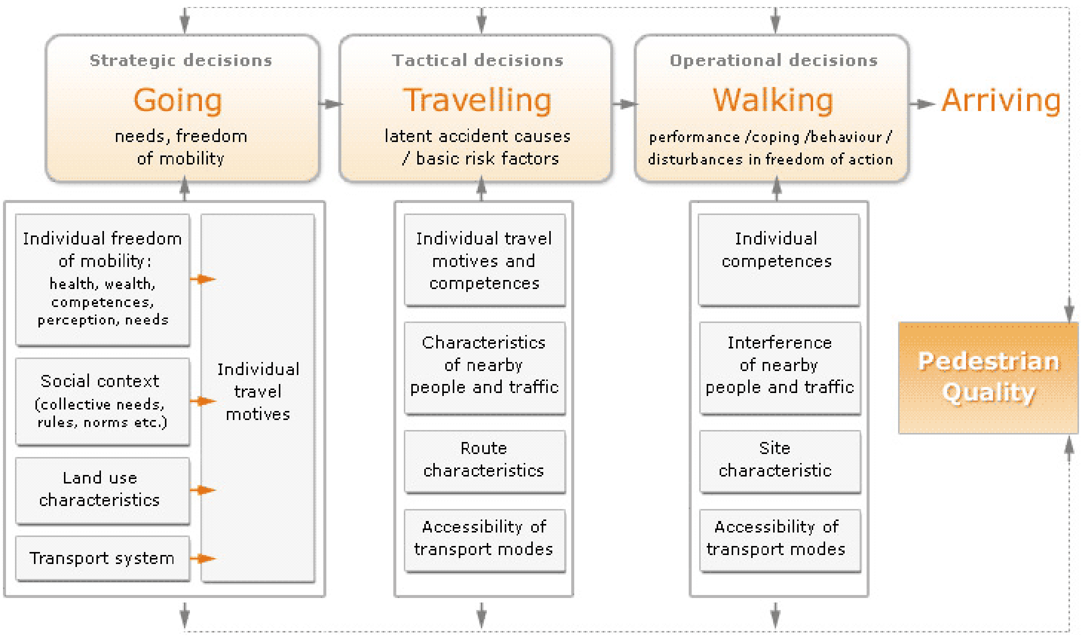


Figure 2 Basic conceptual model Pedestrians' Quality Needs study, http://www.walkeurope.org/images/background/dynamic_model.gif

Determined on the basis of this logic of the project, decisions that are made at different levels of decision-making will be discussed in terms of individual groups of pedestrians. According to this structure we will define the consequences of limitations and functional impairments of different groups of pedestrians.

In the following subsection we will perform the analysis of the conditions for safe movement of pedestrians and the consequences of limitations and functional impairments related to the dominant, singled out groups of pedestrians: children, adults, elderly and persons with disabilities. Besides the selected groups, some groups that are categorized as “others” will be analyzed at the end.

4. Characteristics of different groups of pedestrians

The characteristics of different groups of pedestrians will be presented following the structure of the subsection arranged so that the first part lists the main characteristics of individual groups, than continued running preconditions (physical environment, social environment and transportation access) for the safe mobility of pedestrians that belong to the defined category and in the end, the consequences of limitations and functional impairments considered from the aspect of decision making.

4.1. Children

Children have reduced ability compared to adults due to their developmental immaturity and lack of experience. These differences are not only physical, but also include some characteristics that are acquired through the developmental process of growing up.

General characteristics that can be seen for children compared to adults are:

- Small height
- Diminished peripheral vision
- Reduced attention and cognitive abilities
- Reduced ability to estimate speed and distance
- Difficulties in the direction of providing sound localization
- Unpredictable and impulsive reactions
- Lack of transport schemes and expectations
- Lack of understanding of complex situations

These features differ, depending on the age of a child, and thus can be separated in following groups:

Infants and Toddlers (ages 0 to 5)

At this age, walking skills are just being developed and the children require constant parental supervision. Infants and toddlers have very limited abilities, and feature the following characteristics:

- They are learning to walk.
- They are developing peripheral vision and depth perception.
- They are impulsive and unpredictable.

Young Children (ages 5 to 7)

At a young age, children have unique abilities and needs. Since children at this age vary greatly in ability, it is important for parents to supervise them and make decisions on whether their child is ready for a new independent activity. Children in this age range tend to be:

- Impulsive and unpredictable,
- Limited in their peripheral vision (a sound source is not easily located),
- Limited in training/lacking in experience,
- Thrilled or excited by close calls,
- Short and therefore hard to be seen by drivers,
- Susceptible to darting or dashing out into the intersection,
- Likely to copy the behaviour of adults.

Preteens (ages 8 to 12)

By middle school years, children do have many of their physical abilities developed but still lack experience and training. Now there is greater desire to take risk. Preteens generally:

- Lack experience,
- Walk and ride a bicycle more often than before and at different times (which increases the possibility of crashing),
- Ride more frequently under risky conditions (high traffic),
- Lack positive role models,

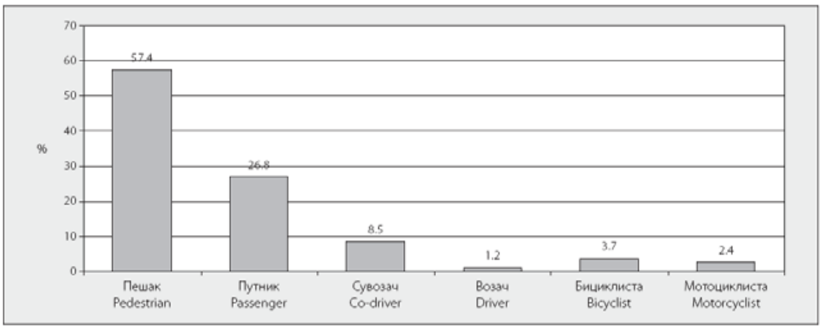
- Cross the street at riskier locations,
- Get involved in more conflict situations with other traffic participants,
- Have a sense of invulnerability that makes them more willing to take chances.

Teens (ages 13 to 17)

By high school and college, exposure changes and new risks can occur. Many walk and ride bicycles under conditions of low light. Other characteristics of this age group are that they:

- Are very active, can go long distances, and visit new places,
- Feel invincible,
- Lack experience and training,
- Are capable of travelling at higher speeds,
- Will overestimate their abilities on hills, curves, etc,
- Attempt to use bicycles, in-line skates, etc., based on practices carried over from youth.
- Are willing to experiment with alcohol and drugs

The exposure of mentioned characteristics we can consider based on the results of the analysis of children's injuries in traffic on the territory of Belgrade, Serbia, conducted at the Institute of Forensic Medicine, Faculty of Medicine and Dentistry, University of Belgrade, has provided the facts and related forms and characteristics of injuries of children in traffic. This research on the territory of Belgrade showed similar results compared to similar studies made in Switzerland, Norway and the UK. The research shows that the most of the children killed were pedestrians - 57.4% (Figure 3), which was statistically significant compared with other categories of road users (Pavlekić & Puzović, 2006)

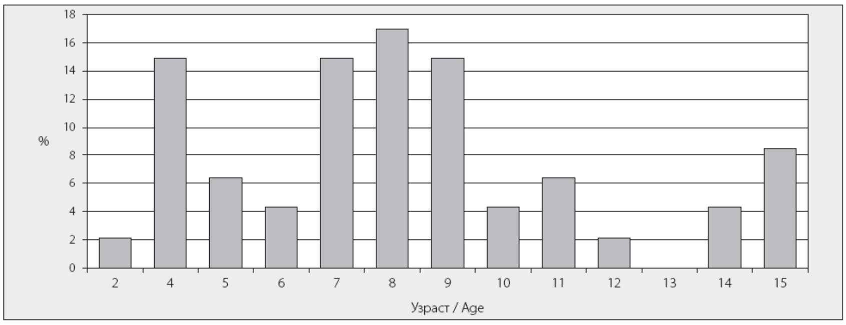


ГРАФИКОН 1. Учесталост смртно страдале деце посматрана по категоријама учесника у саобраћају.
GRAPH 1. Frequency of categories of fatally injured children-participants in traffic.

Figure 3 Frequency of categories of fatally injured children-participants in traffic (Pavlekić & Puzović, 2006)

The analysis of injured pedestrian children's age showed that in 46.8% of the cases they were between 7 and 9 years old, and pupils of lower grades of elementary school. Children at preschool age of four were killed in 14.9% of cases (Figure 4). The average age of children included in this study was 8.1 years (Pavlekić & Puzović, 2006). Boys are slightly more likely to be hurt than girls are. Similar results were recorded in the research conducted in South Australia[4] and Sweden[5].

[4] Byard RW, Green H, James RA, Gilbert JD. Pathologic features of childhood pedestrian fatalities. Am J Forensic Med Pathol 2000; 21(2):101-6.
[5] Hjern A, Bremberg S. Social etiology of violent deaths in Swedish children and youth. J Epidemiol Community Health 2002; 56:688-92.



ГРАФИКОН 2. Дистрибуција смртних случајева међу пешацима дечјег узраста.
GRAPH 2. Age distribution of fatally injured children-pedestrians.

Figure 4 Age distribution of fatally injured chidren-pedestrians (Pavlekić & Puzović, 2006)

The investigation of circumstances of injuries found that in most cases, 51.9%, children cross the street outside the marked pedestrian crossings and carelessly run on the street from unguarded playgrounds and yards during playtime. This is especially related to the injuries of children aged between 7 and 9 years. More than 2/3, precisely, 68.8% of children at this age were fatally injured due careless running on the street (roadway). In contrast, older children aged from 10 to 15 years, were injured while crossing the street at marked pedestrian crossing or while walking on the sidewalk, solely due to negligence of the drivers (Pavlekić & Puzović, 2006). This research also showed that traffic education of children on the territory of Belgrade and Serbia is on a very low level.

4.1.1. Functional preconditions for (acceptable) safe mobility of children with respect to physical environment

Considering the mentioned characteristics and abilities of children at different ages, it is necessary to predict the specific measures for the safe movement of children in relation to the physical environment. The behaviour of children of different ages varies widely, both in physical and cognitive abilities, and this is reflected in their behaviour as pedestrians. Because of their hasty and unpredictable reactions in the earlier age, and then the sense of invulnerability in the latter, especially the lack of experience that characterizes almost all ages, the physical environment in which children spend time must be carefully shaped.

This primarily refers to areas where children spend time playing and having fun outdoors and the distance to the path of movement of other road users. Each intersection of a direction of movement of children and other road users carries a risk of traffic accidents with different levels of consequences.

Spaces where children spend time must be properly located, guarded and provided with lighting. Location of these areas should be in areas in which there are measures to reduce vehicle speed. The provision includes the presence of barriers in critical areas, which would prevent reckless and hurry reactions of children such as run for the ball, etc.

4.1.2. Functional preconditions for (acceptable) safe mobility of children with respect to social environment

Social environment is very important for the proper upbringing of children as participants in traffic as pedestrians, taking in account their limited (undeveloped) cognitive and sensory abilities and lack of experience. Children of different ages should be taught through the education system of values, which refers to the development of traffic culture and the respect for traffic regulations. For those of younger age, especially children aged 5-12 years when they express the characteristic of copying what adults do, it is very important how we behave as adults or parents who have direct involvement.

Upbringing of children involved in traffic should be aimed on improving their safety when they are individual participants in traffic. It is believed that the child before the age of 12 has not developed the necessary skills to make decisions when involved in traffic. Nevertheless, children from the age of 5-6 years are sometimes present in transport, unaccompanied by adults.

Preschool child is not able to make the right decision in traffic situations (Roditelj Portal, 2006). Among the many impressions that attract attention, the most important one is that the preschool child has no ability to differentiate what is important from what is unimportant. Focusing on relevant information and ignoring the irrelevant ones is possible only in the age of 11.

Prediction of the effect is another problem that occurs in the age of preschool children. Causes and consequences can be considered after the age of 8 years. This is considered a very complex situation since it consists of a series of activities such as decryption of an important signal, timing in which the child will make a decision perform an action. In addition, this should include the emotional state of a child. Children make the decisions in traffic too quickly or slowly. Because of this, it is important that the traffic situation in which the child finds itself and needs to make decisions, be simpler and not require a number of abstract information.

In relation to the social aspect, it is very important how the adults behave in traffic, because their behaviour results in providing indirect messages to children. Because of this, it is extremely important how we behave in traffic and how we treat the traffic rules in the presence of children, especially in the presence of preschool children. Personal example and consistency in behaviour of adults is a significant source of knowledge for children aged up to 8 years, because they have a decisive influence on a child.

When adults make a decision to act contrary to the rules in the presence of child, they send indirect negative messages:

- Nothing bad will happen if you pass the street outside the pedestrian crossing or not wait for the green signal at traffic lights to show.
- There are rules, but when you are in hurry, they are not important. Something else is more important than the rules.
- You do not have to take care of everything. The other driver also has to take care of you.
- The accident will not happen to me. It will not happen now when I am in hurry. (Roditelj Portal, 2006)

In contrast to this, the behaviour of adults, which is a good model for the identification of the child, sends the following message:

- I have to respect the rules, because security is more important than any award or penalty.
- There is no good reason to put yourself in danger.
- There is nothing more important than your safety (Roditelj Portal, 2006).

A preschool child has no ability to assess the security situation in violation of traffic rules and therefore must respect the traffic rules consistently and without exception. The personal example of the adult is of a crucial importance for the safety of the child included in moving traffic.

In addition to parents' behaviour as a model for the child's behaviour, it is very important in which period of a child's life do parents decide to allow them to move independently. This depends on the characteristics of the parents themselves, their education, family situation, where they live, etc. Based on a research conducted by the American Medical Association in 2007, the parents believe that children can cross the street independently at the age of 9 and that can drive a bike at the age of 12 (Porter, Crane, Dickinson, Gannon, Drisko, & DiGuiseppi, 2007). The term –independently- means, without direct supervision of parents. This research was aimed to give an advice to paediatricians about the characteristics of assessment of parents about the abilities of their children.

4.1.3. Functional preconditions for (acceptable) safe mobility of children with respect to transportation access

According to a research conducted by the London Department for Transport on how children and young people travel, depending on their age, until the age of 10 years there is very little difference between boys and girls (Figure 5). Both perform the same number of trips and mostly belong to the category of passengers in a private car. The other transport form of children is walking.

At the age when children go to high school, some changes may be noticed. Travel by car decreases in favour of public transportation. The research also showed that boys cross a certain distance by bicycle, while the number of girls increases for travelling in other way (Figure 5).

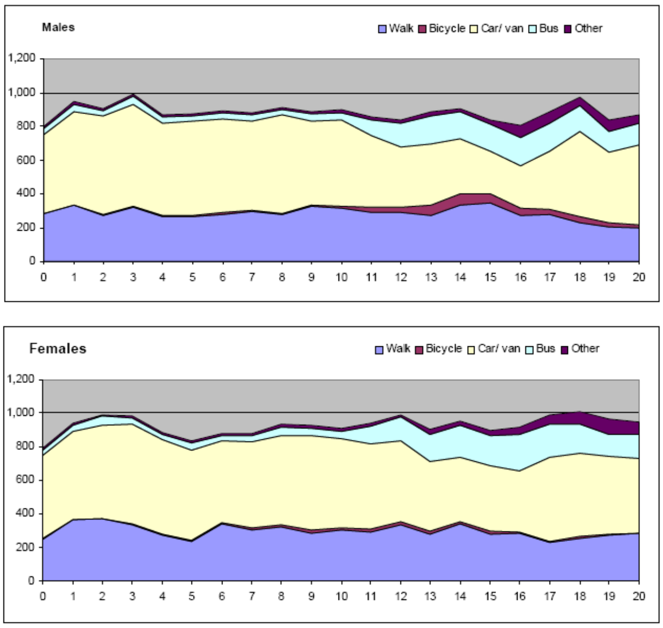


Figure 5 Travel by main form, age (0-20) and gender (London Department for Transport, 2007)

Travel by other forms of transport, including train and taxi, becomes important in a period of over 16 years, while travel by car again increases in the period when young people acquire the conditions to manage their own car.

Given that a large percentage of children aren't old enough and have no financial independence to use their own car as a form of transport, most of the children in addition to walking and biking are dependent on other forms of transport. This means using of public transport or car lifts by their parents.

As for the bus, according to a research conducted by the Department for Transport (Department for Transport, 2007), the key factors that influence the choice of children for some forms of public transport, are the ticket costs, driver behaviour, personal safety, service quality, quality of the means of transport and the level of information given.

Younger people do not have enough experience in other forms of transport like trains, trams or metro. General opinion is that young people from 11 to 19 years (in Britain) have a favourable opinion on intercity trains, but they consider it expensive. For local trains and trams, the same factors as is the case with buses affect the children's choice. Some of the respondents said that they would not travel with the local train or tram in the evening, because of fear of crime.

Metro has been described as an expensive form of transport for children aged 11 to 19 years who live London. However, this form of public transport is considered justified when it is used for greater distance.

Most of the surveyed young people indicated that their parents give them lifts when it is necessary. These statements are confirmed by parents who would rather give their children a lift to a specific destination instead of allowing them to use public transport or walk. The reason for this, in addition to safety, is that parents also wish to supervise their children.

4.1.4. Consequences of limitations and functional impairments of children

Considering the principles of making decisions at three abstract levels, children as a separate group of pedestrians show a specific behaviour. This behaviour largely depends on factors related to the physical requirements for the movement of children of different ages, but also on their needs, related to a specific age.

Strategic level of decision making with children is determined by several criteria. According to a research conducted and published by the London Department for Transport (Department for Transport, 2007), the reason why children travel varies depending on their age. Young children are accompanied (usually by their parents or someone older than they are) more than half of their total outdoor and public movement. Most of the other reasons for travel are shopping, personal affairs or entertainment. From their second year of life, a decline in travelling as an escort occurs, while the number of travels whose purpose is education increases.

Starting from 5 to 15 years, the movement with a purpose of education represents 35-40% of the total number of children's trips (Figure 6). From 15 years of age, children usually move with the purpose of working. The difference between boys and girls who are teenagers, the number of movements whose purpose is shopping is in favour of the girls.

From a previous research, we conclude that the most common purpose of travel for children and young people (up to 20 years) is education and entertainment. Other travel purposes, which are listed in the previous study, appear on a much smaller scale for children who are accompanying the adults while they perform their activities or are related to young people of 15 years of age.
On a tactical level of decision making for children, their independence is an important criterion. According to a research conducted and published by the London Department for Transport, 79% of children aged 7 to 10 years are accompanied by the adults, contrary to 23% of children aged 11 to 13 years. (Department for Transport, 2007) The reasons why their parents behave like this either are the risks of other forms of transport (58%) or fear of attacks and abuse of their children (45%). As reasons for escorting the older children,

parents entice the greater distance from school (32%), the risk of other forms of transport (30%) and fear of attacks and abuse (26%).

In addition to this, the survey included the question in which age do parents allow children to cross the street alone. The results are shown in the Figure 7.

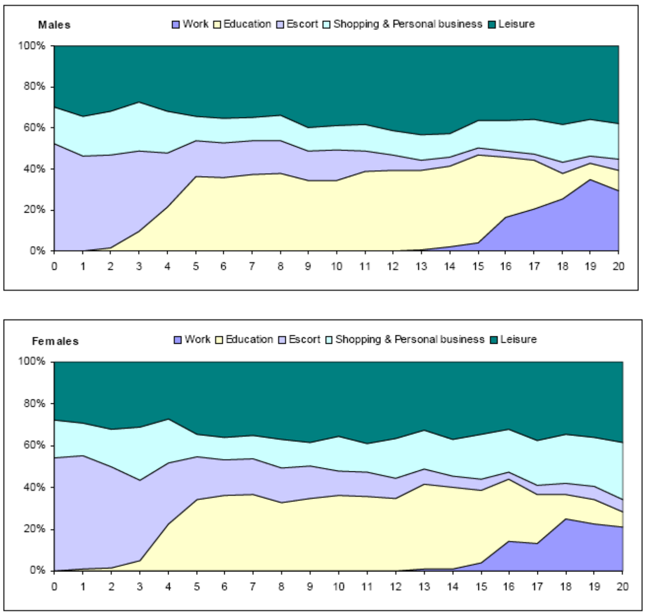
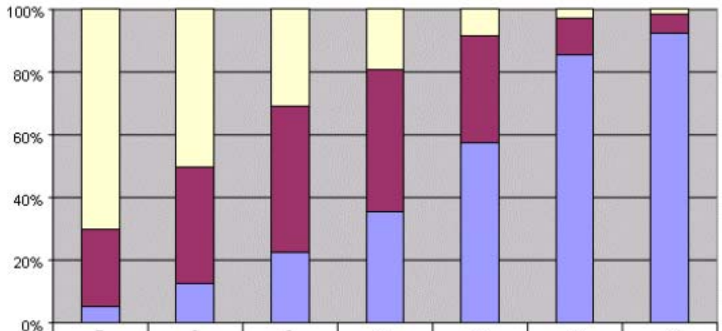


Figure 6 Travel by purpose, age (0-20) and gender (London Department for Transport, 2007)



	7	8	9	10	11	12	13
Never	70	50	31	19	8	3	2
Sometimes	24	37	47	45	34	11	6
Almost always	5	12	22	35	57	86	92

Age

Figure 7 Children crossing roads alone (London Department for Transport, 2007)

Operational level of decision-making really depends on developmental age of the child or of its physical, psychomotor, sensory and cognitive abilities. Development of these abilities is linked to aging and health of the child. As previously shown in a number of cases, the parents make decisions on their child's movement, and this largely depends on their subjective assessment in related to the ability of the child.

According to the specific characteristics of children as identified group of pedestrians we can specify the main reasons and barriers for walking of children. They are presented in Table 3.

Also, we identified the factors that influence strategic, tactical and operational level of decision making of children, which are presented in Table 4.

Table 3 Reasons and barriers for walking of children

Mode of transport	Psychological/emotional	Practical/functional	Economic
Walking (+)	Purpose Entertainment	Local trips for pupose	No cost
Walking (-)	Independence Fear of crime	Age Poor weather Parental accompany	

Table 4 Factors that will influence different levels of decision

Mode of transport	Strategic	Tactical	Operational
Walking	Purpose Entertainment No cost Local trips Limited distances	Age Independence Fear of crime	Age Health conditions Poor weather

4.2. Adults

If we look at this group of pedestrians, concerning the characteristics and abilities of pedestrians, we might consider that this group fully performs traffic movement, with minor oscillations. Oscillations in abilities mainly differ between men and women, while among the members of the same sex may vary in relation to the physical characteristics and physical fitness.

Adult pedestrians are persons aged 19 to 65 years. Within this category, according to the age, two groups are distinguished with certain differences in characteristics and abilities (U.S. Department of Transport, 2009):

Adults (19 to 40)

These adults are highly competent in traffic and capable of perceiving and dealing with risk in most circumstances. Some use bicycles for commuting and utilitarian trips, while others use bicycles primarily for recreation. This group is generally:

- Active and fully aware of the traffic environment,
- Comprises only 1–4 percent of bicycling population in most communities,
- Tend to be very vocal and interested in improving traffic conditions.

Middle-Aged Adults (41 to 65)

During this stage of life, many pedestrians experience slower reflexes necessary to observe, assess, and respond to traffic conditions.

Besides these characteristics, the behaviour of this group of pedestrians will generally depend on other factors such as interest, professional orientation, employment status, income, etc. Considering the previously mentioned factors of these adults, as the singled-out group of pedestrians, three dominant groups can be noticed (allocated by some authors) among which there are some differences in concerning: income, ethnicity and religious affiliation (belonging to minorities) and a place of living (depending on whether they live in urban or rural areas).

4.2.1. Functional preconditions for (acceptable) safe mobility of adults with respect to physical environment

The kind of the physical environment we have nowadays is shaped and adapted for the "average user", which is the most common population. Concerning the physical environment, the needs of the adult pedestrians are mostly aimed at improving the quality of individual factors such as security, accessibility, comfort and attractiveness.

Depending on the place of residence, the primary precondition for the safe movement is the existence of a space in which fear and the degree of chances for injury are minimized. This primarily refers to the urban areas, which do not belong to the city centre or a local centre, and rural areas or areas where the poorer population lives. According to some research, the highest percentage of pedestrians belongs to groups of poorer people.

In addition to these areas, due to lack of content that would attract many people (such as the central area of the city), and because of low attendance and presence of other people, the fear is increased and this is the most apparent with the female population. Inadequately moderated, poorly maintained, and dark areas increase the feeling of insecurity and fear.

In rural or suburban areas, accessibility emerges as a precondition that should be fulfilled. Here, accessibility includes the distance of content and services that are necessary for daily life and distance of stations for other forms of transport that connect rural areas with local and regional centres. According to a research published by the London Department of Transport, 51% of rural households are less than 13 minutes away from the nearest bus station, in contrast to 96% of urban households. What this reveals is that, in general, most of the working population saw walking as an alternative for crossing a very short distance, whereas only 6% of the population considers walking an alternative to using a car (London Department of Transport, 2006).

Research published by the London Department of Transport shows that, within the population of a working age, over a half of the respondents use a car for crossing the walking and cycling distances. However, despite these results, 90% of the respondents said that people should walk because of their health, environment protection and the reduction of pollution (London Department for Transport, 2003). A possible reason for choosing to drive instead of walking is that the pedestrian environment should improve. In addition to the above-mentioned conditions, concerning security and accessibility, comfort and attractive surroundings are also important.

4.2.2. Functional preconditions for (acceptable) safe mobility of adults with respect to social environment

Functional preconditions for the safe movement of adults related to the social environment are linked to the concept of social exclusion and inclusion that are generally associated with a sense of security when walking. The degree of social inclusion of adults is viewed concerning the extracted subsets of pedestrians that differ according to the material status, ethnicity and religious affiliation and place of residence.

According to the report made and published by Social Exclusion Unit and the Department of Transport, walking is the most common form of movement in traffic of people with lower incomes. People in households of **lower incomes**, having no car, walk in 58% of their movement, compared to only 17% of people in households with high incomes who own a car (London Department of Transport, 2007). As mentioned, the movement of this category of the population may be limited to the local area, which may result in exclusion from social activities such as finding a better job, education, supplies, etc. In addition to this, areas in which poor people live are often poorly maintained and dark which leads to increased fear and risk from attack and abuse.

Social groups that are distinguished by ethnic and religious affiliation are faced with **fears of attacks and problems** on this basis. In addition, the problem may be the language barrier. This contributes to a lower ability to understand information that would assist them in better orientation and travel planning.

Pedestrians who live in suburban and rural areas face the problems that are in most cases related to the **distance and inadequate pedestrian environment** (lack of footpaths or inadequate maintenance and equipment). First problem affects the reduced opportunities in terms of content and activities and the others is an increase in the level of fear when walking.

Critical groups, such as the poor, the minorities and people who live in suburban and rural areas, could be excluded from the rest of society and relate exclusively to their group or environment where they live. If we tend to create the pedestrian environment which is socially inclusive, it is necessary to remove the obstacles that cause social exclusion, especially those which concern security of individuals and their groups.

4.2.3. Functional preconditions for (acceptable) safe mobility of adults with respect to transportation access

Most of the adult population has the access to different forms of transport. The differences can be seen concerning the selected subcategories of working population that was previously mentioned.

As previously stated, the majority of adult pedestrians walk only when it comes to overcoming **short distance or for recreation and relaxation**. The main conflict situations with other forms of transport are with the population of working people aged over 50 years. This specified age is a stage of life in which individuals face the body disorders that can affect any of the listed abilities of a human (physical, sensory, mental and psychomotor).

For the poor members of the population, the access to other forms of transport is limited by the height of costs. This is the reason why they are limited to walking as a form of transport. In the case of subcategories related to ethnic and religious affiliation, there are restrictions concerning the safety of an individual when using the public transport services. (Department of Transport, 2007) Pedestrians who live in suburban or rural areas list the large distance (over 13 minutes) to the nearest station of public transport as the main problem (in case they do not have their own car).

A problematic situation may arise due to inadequate equipment and lack of pedestrian infrastructure, which means that pedestrians move in spaces reserved for another transport means (roadway, railway, etc.)

4.2.4. Consequences of limitations and functional impairments of adults

If you observe abstract levels of decision-making in terms of walking, adults are a category of pedestrians who have all the preconditions for normal motion, concerning the physical, psychomotor, sensory and mental abilities. Their decisions will be affected by other factors, such as the purpose of travel, their income, ethnic and religious affiliation (if they belong to minorities), place of residence (depending on whether they live in urban or rural areas), etc.

The main reasons for travelling adults are classified into four broad categories whose purposes are their job, as a "suite" (such as tracking children to school), shopping and conducting personal business and entertainment. If you observe the results of a research on the purpose of pedestrian movement (Figure 8), regular travels and shopping are distinguished for a group of pedestrians ageing from 16 to 69 years (which is slightly greater than the interval discussed in this paper).

Percentage of trips

	0-15 years	16-25 years	26-54 years	55-69 years	70+ years	All 16+ years	All ages
Commuting	-	23	23	13	1	19	15
Business	-	3	6	4	-	4	4
Education	27	11	-	-	-	2	6
Escort education	5	2	7	1	1	4	5
Shopping	8	15	19	29	38	22	20
Other escort	15	5	10	7	4	8	9
Other personal business	8	7	9	14	19	11	10
Visit friends at private home	17	16	9	10	13	11	12
Visit friends elsewhere	3	7	4	5	5	5	4
Sport/entertainment	9	7	5	7	8	6	7
Holiday/day trip	4	3	3	5	5	4	4
Other including just walk	3	2	4	5	5	4	4
All purposes	100	100	100	100	100	100	100
Base (unweighted)	4,150	2,128	7,671	3,485	2,470	15,754	19,904

Figure 8 Proportion of walking trips per person, per year, by purpose (London Department of Transport, 2007)

Small differences in frequency are seen in walking, between men and women, but there are differences related to age. According to a research published by the London Department of Transport, only 3% of people aged 16 to 44 years walk at least 10 minutes a day, but this percentage increases to 9%, according to the increase of age. (London Department for Transport, 2003)

There are differences in the frequency of walking conditioned by place of residence. According to the same survey, 92% of respondents that live in urban areas walk 10 more minutes at least once a week, in contrast to 86% of respondents who live in rural areas.

As mentioned earlier, most adults consider walking an alternative kind of movement (transport) and choose this form of transport only for short distances. Shorter distances mean walking to other forms of transport, such as a private car, the public transport stations, etc. or movement in their immediate environment in order to perform everyday purchases and personal affairs.

At the tactical level of decision-making, continuity of movement will be affected by distance and characteristics of physical and social environment. The influences of these characteristics differ from the subcategories of the working population, based on income, place of residence and ethnic and religious affiliation.

At the crossroads, and for safety when crossing the streets, adults have all the preconditions to perform all the actions without any great difficulties. On the other hand, speed of adults will depend on the characteristics of the terrain, distance, movement and depending on whether they move independently or accompanied by one or more persons. Depending on who they are moving with (the child in the wheelchair, the elderly, persons with disabilities), the adults will, in most cases, adjust their speed and gait according to the person (persons) that are moving with. These facts can affect the tactical level of decision making when choosing walking as a form of movement.

Adults have all the advantages that enable them to make decisions easily on an operational level because, in most cases, they are very much able to perform the action of walking. However, the operational level of decision-making in adults, similar to the tactical level, may depend on the cases when they move with other people. Depending on the characteristics and state of other people or creatures that move with the adults, (children, elderly, people

with disabilities, dogs, etc.) the method and the characteristics of movement will be adjusted to the person accompanying them.
In relation to the specific characteristic of the adults as identified group of pedestrians we identified the reasons and barriers for walking of adults. Those results are presented in the following Table 5. Also, we identified the factors that influence strategic, tactical and operational level of decision making of adults, which are presented in Table 6.

Table 5 Reasons and barriers for walking of adults

Mode of transport	Psychological/emotional	Practical/functional	Economic
Walking (+)	Purpose Recreation Relaxation Entertainment	Short distance trips for recreation and relaxation Well mentioned environment	No cost
Walking (-)	Fear of crime Fear of attacks and problems Belonging to the different ethnical, regious and racial groups	Distance Inadequate pedestrian environment Place of living Material status Accompany Poor weather	

Table 6: Factors that will influence different levels of decision

Mode of transport	Strategic	Tactical	Operational
Walking	Purpose Place of residence Adequate pedestrian environment	Fear of crime Fear of attacks and problems Belonging to the different ethnical, regious and racial groups Material status	Adequate pedestrian environment Accompany Poor weather

4.3. Elderly

In PQN[6], ageing is defined as the demographic process in which the proportion of the elderly increases. The elderly are usually defined as people of 65 years and older. With regard to walking elderly people of 80 years and older is a much more functional definition[7].

Based on characteristics and abilities of pedestrians in this category, we can recognize certain variations. They are a consequence of the gradual decline of physical and cognitive functions, which are quite visible after 75 years of life. Bearing in mind that these changes could affect any or several categories of abilities (physical, psychomotor, sensory or cognitive); older pedestrians generally exhibit the following characteristics and behaviours (U.S. Department of Transport, 2009):

[6] Pedestrian Quality Needs Glossary
[7] The generation between 65 and 80 do not have serious troubles walking, except when they have one or more handicaps. One has to bear in mind that among the 80+ there are many that are in excellent physical condition, are able to walk quite fast and do not have any serious handicap when walking. They are however more fragile than younger generations.
There is some empirical evidence that there is a ‘fear factor’ from speed of cars by people of over 65, which might be explained by uneasiness facing the acceleration of life in general. As a perceived risk, it needs to be addressed.

- Walk more in older years, especially for exercise/independence,
- May have reduced income and therefore, no car,
- All experience some reduction in vision, agility, balance, speed, and strength,
- May have further problems with hearing, extreme visual problems, and concentration,
- Have the tendency to focus on only one object at a time,
- Have difficulty hearing vehicles approaching from behind,
- All have greatly reduced abilities under low light/night conditions,
- May overestimate their abilities,
- Have a higher fatality rate than other pedestrians do, when involved in collisions with motor vehicles (Table 7)

The Critical Review of the Literature about Older Pedestrians[8] considers the effect of ageing on older people's vision, hearing, physical mobility, and cognitive processes. Although the changes experienced are well established, there has been little direct research linking functional decline to older pedestrian accidents. There were identified the principal changes most likely to affect pedestrian skills, which are listed below. They conclude that the age at which difficulty is experienced, and the extent of impairment, varies greatly between individuals. Some parts of the text from the Review are quoted below.

Vision and hearing

Older people tend to have poorer vision, seeing objects less clearly both closes up and at a distance. They cope less well with seeing in poor light conditions, and adapt more poorly to glare. Their ability to detect and identify moving objects also decreases.

According to a research from USA, 50% of 65–74 year olds, and 75% of those aged 75+, have been estimated to have cataract. Macular degeneration affects 25–30% of those aged 60– 75 and 40–60% of those aged over 75. By the time people are aged 70, low frequency hearing loss is about 13dB and high frequency loss 36–47dB. These visual and hearing problems could make it harder to detect or locate vehicles or other hazards, especially in darkness.

Physical mobility

As people get older, the difficulties in mobility increase. The UK National Travel Survey (NTS) found that about 50% of men and 70% of women aged over 80 years who were interviewed; report that they had physical problems that made walking in the outdoors difficult. Most of those who report some difficulty are able to get out and down the street, although some need help to do so.

Older people walk more slowly, making it more difficult to cross roads safely, especially when the time available to cross is restricted by short gaps in traffic flow or short "green man" times at pedestrian crossings. Measurements of walking speed have shown great variation among older people and between studies. The largest reductions in walking speed are caused by illness. Consequently, even quite conservative fixed signal timings will not allow enough time for some older people.

Reduced ability to make head and neck movements could affect viewing. Older people are less able to change speed or direction quickly to avoid hazards, and are more likely to have problems with balance. Older people, particularly women, are vulnerable to falling in the road environment. Several studies suggest that falls on footways caused injuries that are more serious for older people than collisions with road vehicles do.

[8] Dunbar, G., Holland, C. A., & Maylor, E. A. (2004). *Older Pedestrians: A Critical Review of Literature.* London: Department of Transport. pp. 11-12

Table 7 Characteristics of older pedestrians, adapted from NZ, Land Transport. „Pedestrian planning and design guide. " Land Transport NZ. 04 2008.

Group of abilities/ characteristics	Characteristic	Resulting in	Impacting on
Physical abilities and characteristics	**Decreased agility, balance and stability**	Difficulties in changing level	Provision of steps/ramps Kerb height Gradients Handrails Surface quality
	Reduced stamina	Shorter journeys between rests	Resting places Shelter
Psychomotor abilities and characteristics	**Reduced range of joint motion**	Slower walking speed	Crossing times Mean journey length
	Slower reflexes	Inability to avoid dangerous situations quickly.	Crossing opportunities
	Reduced manual dexterity and co-ordination	Reduced ability to operate complex mechanisms.	Pedestrian-activated traffic signals
Sensory abilities and characteristics	**Vision problems, such as reduced acuity and poor central vision**	Reduced ability to scan the environment	Ability to detect and avoid objects Sign legibility Kerb detection Crossing locations Trip hazards Maps
	Reduced tolerance for adverse temperature and environments	Preference for sheltered conditions	Route location and exposure
	Increased fear for personal safety and security	Fear of using all or part of a route.	Lighting Surveillance Lateral separation from cars. Provision of footpath Traffic speed and density
Cognitive abilities and characteristics	**Limited attention span, memory and cognitive abilities**	Needing more time to make decisions, difficulties in unfamiliar environments, lack of understanding of traffic signals	Positive direction signage 'Legibility' of streetscape Consistency of provision

Cognitive processes
Reaction time slows with age, and the ability to divide or switch attention reduces. Research with children has linked attention switching to viewing behaviour in the road environment. A composite measure of cognitive function termed UFOV (Useful Field Of View) has been correlated with accident risks for older drivers, particularly accident risk at intersections. It is also believed that older people with sensory loss or physical mobility changes need to allocate more of their available cognitive human abilities to cope with complex situations and their capacity to respond quickly and flexibly to changing circumstances.

Health
Certain medical conditions, including some psychopathologies, lead to abnormal levels of decline of vision, hearing, physical mobility, and cognition. Cerebra-vascular accidents (strokes), in particular, can lead to severe impairment. Eye diseases such as cataract can seriously impair vision. Dementia affects sensory and cognitive processes, and it is known to be associated with higher accident risk for drivers. These conditions are common among older people, and prevalence increases with greater age. Many older people will be coping with more than one condition alongside the effects of normal ageing. The medication required for a number of conditions is known to affect abilities and behaviour in ways that could influence road safety. Little research has assessed the practical impact of health problems on pedestrian behaviour or their relationship with accident risk. A British survey of 302 people with visual impairments found that 29% had had an accident crossing the road, 94% just walking and 33% while climbing steps. These rates are much higher than published rates for the whole population.

Compensation
Studies of the perception of older people on their own declining capacity suggest that they have good awareness when there is a clear feedback from the environment. Declining perception capacity is expressed in the form of difficulty with everyday tasks, such as reading small print, but can also be determined by professional eyesight experts. However, older people's reports of cognitive problems may be an indirect reflection of depression. Certain conditions such as dementia affect the insight into declining capacity. Older people, who believe they are performing not as well, modify their behaviour in ways that, on the surface, ought to reduce accident risk. For example, many older drivers avoid driving at night. However, there is no direct evidence that older pedestrians are effective in reducing their accident risk through such compensatory behaviour. (Dunbar, Holland, & Maylor, 2004)

4.3.1. Functional preconditions for (acceptable) safe mobility of elderly with respect to the physical environment

Based on the above-mentioned characteristics of the elderly, most of the preconditions for the safe movement of elderly pedestrians are related to the physical environment. Pursuant to the physical, psychomotor, sensory and cognitive changes that begin to be manifest through aging, physical environment should be adapted for safe movement of this group of pedestrians.

Walking is very popular with the population of older people since it improves health and offers a kind of pleasure. However, as previously mentioned, there are a number of old people unable to walk greater distances due to their limited physical abilities. Contrary to adults, the basic preconditions for the movement of the elderly in relation to the physical environment are safety and accessibility.

Due to the specifics of this category, walking environment should be shaped in a way in which potential obstacles can be avoided that might affect the movement of the elderly or make it more difficult. First, pedestrian paths should be clearly separated from the paths of other forms of transport. Furthermore, places of intersection (stations of public transport and crossings) should be adapted according to the needs of older people. In the process of creation of the sidewalks and trails, places of different height (step, ramp, etc.) should be avoided. Moreover, if that cannot be avoided, then they should be clearly specified and with installed handrails, which would facilitate the overcoming of various heights. Older people get tired quickly, so it is necessary to predict resting places on adequate distances.

Intersections with other forms of transport should be clearly marked so that they can easily be spotted. Specific measures for traffic speed reduction have to be introduced as well. This is needed for the minimization of tragic outcomes caused by negligence and poor coordination of the elderly. Traffic signalization at intersections should be formatted and set in an easily visible way and adapted to the speed of movement of the elderly.

A shelter from the wind, rain and other inclement weather is necessary to predict because older persons have increased body sensitivity to weather conditions and temperature changes. Pavements used for footpaths should not change their characteristics in different weather conditions.

Elderly people show fear for their own safety and security. Because of this, they avoid going anywhere during the evening especially if they have to pass through the increased traffic intensity places. Directions with adequate lighting, separation from other forms of transport and measures for calming the traffic down should prevent this.

One of the ways we can improve quality of life of older people and allow their independency, is by following the concept of ˝Walkable Neighbourhood˝. According to Cannolly, within the ”Walkable Neighbourhood”, old people are able to move independently and reach the desired destination (shops, bank, ambulance) by walking, in about 15 minutes around. (Department of Transport, 2007) In a Neighbourhood designed like this, safety and accessibility are the priorities.

4.3.2. Functional preconditions for (acceptable) safe mobility of elderly with respect to the social environment

Social exclusion is one of the important topics in research and literature, related to the elderly. According to a research and the facts provided by Social Exclusion Unit, restrictions in motion with various types of transportation can be a barrier to social inclusion and independence of older persons.

Research about the role of traffic in social exclusion, which are made by Barnes during 2005[9] shows seven dimensions of social exclusion (Department of Transport, 2007):

- *Social relationships* (contact with family and friends),
- *Cultural and leisure activities* (for example, going to cinema or theatre),
- *Civic activities* (membership of a local interest group, voluntary work, voting),
- *Basic services* (for example, health services, shops),
- *Neighbourhood* (for example, safety and friendliness of local people)
- *Financial products* (for example, bank account, pension),
- *Material goods* (for example, consumer durables, central heating)

Inability and limited movement may result in the emergence of a certain notion of multiple exclusions, which means the exclusion of three or more of the above-mentioned dimensions.

[9] Published by Department of Transport in 2007

If we take the wider context of traffic into account, reduced mobility and accessibility to different forms of transport (private car, public transport, taxi, etc.) represent the factors that directly affect the sense of loneliness and social isolation of older people.

If we consider walking as autonomous from other forms of transport, from the angle of elderly people this means: a physical and pleasurable activity, faster transportation for local distances, activity that improves health and mobility and it is free.

For elderly people, restrictions in mobility, which were not caused by physical, psychomotor, sensitive and cognitive limitations, but originate from other factors, not only make walking an impossible form of movement to a certain destination, but also deprive them of a pleasant leisure activity. This way, older people may be denied a form of entertainment, or the possibility of walking combined with other everyday activities like shopping, as well as the opportunity to meet with friends and family, or to perform some other form of socialization.

From all of this, we can see that the basic precondition for the safe mobility of the elderly, in the context of social environment, is the removal of all potential factors and barriers that could exclude, in any way, this category of pedestrians from society.

4.3.3 Functional preconditions for (acceptable) safe mobility of elderly with respect to transportation access

Abilities of older people in most cases will affect the potential type of movement. According to a research published by the London Department of Transport, old people use the following forms of transport (Figure 9):

- Car
- Bus
- Underground
- Tram
- Train
- Taxi
- Lifts
- Walking

- Cycling
- Coaches
- Post office van (providing bookable lifts between villages)
- Mobility scooters
- Dial-a-ride
- Community transport
- Hospital transport

Figure 9 Modes of transport used by older people (London Department of Transport, 2007)

On the left side, we can see the frequently used forms of transport and on the right, the modalities that are represented in lesser extent in this population.

Continuation with the expected functioning, in conditions when their physical abilities are on the decline, different forms of transport should be adapted to the needs and capabilities of the elderly. This can be achieved by removing barriers and reducing the potential movement difficulties of elderly people.

4.3.4. Consequences of limitations and functional impairments of elderly

According to a research conducted by the London Department for Transport, published in the "*Understanding the travel needs the behaviour and aspirations of people in later life"*, three basic categories are found related to the purpose of movement of elderly people: social and recreational, and everyday personal and business. (London Department of Transport, 2007) Social and recreational activities for people in an older age include activities such as going to lunch, socializing with friends, visiting a local club, or doing hobbies. Daily and personal activities include shopping, going to the doctor, dentist or a hairdresser. Business activities include work, or doing certain activities that are related to their job (this study included the part of the random population aged above 50 years). In our case, activities considered bind to the population aged over 65 years, majority of them unemployed, so travelling with the purpose of performing work is excluded.

To fulfil their needs, older people must navigate to specific destinations, which are mentioned in the survey: the nearby city centre or a larger city, the local environment, periphery or going to another city, the site located at the other end of the country, abroad, etc. (London Department of Transport, 2007) Featured destinations are mainly related to the purpose of movement. As the main advantages and barriers to walking as a mode of movement, the old people say (Table 8):

Table 8 Reasons and barriers for walking of elderly people

Mode of transport	Psychological/emotional	Practical/functional	Economic
Walking (+)	Leisure activity	Quick local trips Maintaining health and mobility	No cost
Walking (-)	Fear of crime	Poor weather Limited distances Health conditions	

The main factors related to a destination where the planned activity will be performed are the quality of local infrastructure, health conditions of an individual and costs. In addition to this, we can see that people tend to combine several activities in one trip. They usually travel during the day by choice, and tend to avoid walking in the evenings, during rush hours, or at times when children are returning from school.

Tactical level of decision making related to pedestrian movement depends on the health and abilities of an individual and the level of assessment of the physical environment and provided equipment that meets the needs of older persons. By this, we consider the existence of places to rest on an adequate distance, because the seniors quickly get tired, and adaptation to the intersection with other forms of traffic for safe moving of old people, obvious and well-adjusted signals, pavement quality, etc.

At the operational level of decision-making, the important factor will be the health condition of the individual in terms of walking abilities, or a condition in which the individual is while performing an action, or after performing the desired action. The number of elderly people was tested in the research of the Department of Transport pleaded to feel pain when walking, or after performing this action. However, the interesting thing is that old people usually understand the importance that walking has on their health, so even when they feel the difficulties and inconvenience, they still decide to walk.

Factors that influence different levels of decisions are shown in next table (Table 9).

Table 9 Factors that will influence different levels of decision making

Mode of transport	Strategic	Tactical	Operational
Walking	Leisure activity No cost Quick local trips Maintaining health and mobility Limited distances	Fear of crime Fear from other traffic users Health conditions	Maintains health and mobility Health conditions Poor weather

4.4. People with handicap

People with disabilities are also more likely to be a part of the pedestrian group, since some physical limitations can make driving difficult. According to FHWA publication on providing access (1999), disabilities can be divided into three categories: mobility, sensory, and cognitive disabilities.

People with mobility impairments include those who use wheelchairs, crutches, canes, walkers, orthotics, and prosthetic limbs. However, many people with mobility impairments do not use assistive devices. Characteristics common to people with mobility limitations include substantially altered space requirements to accommodate assistive device use, difficulty in passing over soft surfaces, and difficulty in passing over surfaces that are not leveled.

Although people with sensory disabilities are more commonly thought of as totally blind or deaf, partial hearing or vision loss is much more common. Other types of sensory disabilities can affect touch, balance, or the ability to detect the position of one's own body in space. Color blindness is considered a sensory defect.

Cognition is an ability to perceive, recognize, understand, interpret, and respond to information. It relies on complex processes such as talking, memory, learning, and recognition. Cognitive disabilities can hinder the ability to think, learn, respond, and perform coordinated motor skills. Such individuals might have difficulty navigating through complex environments, like streets, and might become lost more easily than other people might.

For those of us fortunate to live to an older age, 85 percent will have a permanent disability that limits our range of mobility. Disabilities are common through all ages, and the permanently disabled people make at least 15 percent of our population. Those with permanent physical disabilities, often kept away from society in the past, are now walking and bicycling regularly. Many others have temporary conditions, including pregnancy, and broken or sprained limbs that may restrict their mobility.

According to type of handicap, we can identify four main groups of pedestrians: mobility-impaired pedestrians, sensory-impaired pedestrians, pedestrians in wheelchairs and mentally impaired pedestrians.

Mobility-impaired pedestrians

Mobility-impaired pedestrians are commonly thought of as using devices to help them to walk, ranging from canes, sticks and crutches to wheelchairs, walkers and prosthetic limbs. However, a significant proportion of those with mobility impairments do not use any visually identifiable device.

We can see, from the table (Table 10), that pedestrians with difficulties in movement have limitations in physical and psychomotor abilities. These limitations result in slower motion, the need for greater space for movement, the level of difficulty in movement, the need for frequent rest and inability to control complex machines.

Sensory-impaired pedestrians

Sensory impairment is often mistaken as being a complete loss of at least one sense, but a partial loss is far more common. Vision impairment mainly affects pedestrians' abilities, although to some extent hearing and proprioception (the ability to sense the location of parts of the body) can also have an effect

Table 10 Characteristics of mobility-impaired pedestrians, adapted from NZ, Land Transport. „Pedestrian planning and design guide. " Land Transport NZ. 04 2008.

Characteristic	Resulting in	Impacting on
Extra energy expended in movement	Slower walking speed	Crossing times Journey length Surface quality
Use of mobility aids	Increased physical space and good surface quality needed	Footpath width Footpath condition Obstructions Step depth Gaps/grates
Decreased agility, balance and stability	Difficulties in changing level	Provision of steps/ramps Kerb height Gradients Handrails Surface quality
Reduced stamina	Shorter journeys between rests	Resting places Shelter
Reduced manual dexterity and coordination	Reduce ability to operate complex mechanisms	Pedestrians-activated traffic signals

Table 11 Characteristics of sensory-impaired pedestrians, adapted from NZ, Land Transport. „Pedestrian planning and design guide." Land Transport NZ. 04 2008.

Characteristic	Resulting in	Impacting on
Reduction in hearing ability	Missing audible clues to traffic	Need to reinforce visual information
Lack of contrast resolution	Reduced ability to distinguish objects	Scan legibility Small changes in level
Reduced vision	Reduced ability to scan the environment	Kerb detection Crossing locations Trip hazards Consistency of streetscape
Severe vision impairment	Use of mobility aid, guide dog and/or tactile feedback to navigate	Streetscape legibility Tactile paving use

From this table, we can see that these people have limitations in sensory abilities, and that most of them are related to vision and hearing (Table 11). Limitations in the sensory abilities result in the impossibility of observing other road users, the impossibility of distinguishing objects, inability to perceive the environment, using aids such as a dog companion or some form of tactile guidance.

Wheeled pedestrians

Wheelchair and mobility scooter users can legitimately use the pedestrian network, but in many ways, their characteristics are very different from those of pedestrians who walk. This means that the network has to function differently when considering these users.

From the previous observation, we can conclude that people who are classified in this subcategory have limitations in three categories of abilities physical, sensory and psychomotor. Because of these restrictions, the width required for the movement should be increased, providing fewer possibilities for balance loss, neutralisation of lower observing height level, and reduced speed when moving uphill and increased speed when moving on flat surfaces or downhill.

Mentally impaired pedestrians

Category of persons with disabilities includes people with mental disorders. These people have restrictions in all categories of skills, but the most of them are related to the psychomotor and cognitive abilities. These damages may result in poor orientation in space, the impossibility of understanding the signals and information, the inability of fast reactions, inadequate assessment of traffic, etc.

Table 12 Characteristics of wheeled pedestrians, adapted from NZ, Land Transport. „Pedestrian planning and design guide. " Land Transport NZ. 04. 2008.

Characteristic	Resulting in	Impacting on
Chair/scooter width effectively increases the width of pedestrians	Greater width required to use a route or pass others	Route widths (including across roads) Street furniture placement Surface quality
Reduced stability	Greater potential for overbalancing	Up stand/sudden changes in gradient Cross fall Maximum forwards and sideways reach to pedestrian-activated traffic signals
Height/User is seated	Lower vision level	Location of pedestrian-activated traffic signals Position of signs
Reduced agility	Increased turning radius (and turning circle)	Places to turn around Horizontal alignments Surface quality
More susceptible to effects of gravity	Slower speeds travelling uphill, faster speeds travelling on level surfaces or downhill	Route gradients Interaction with walking pedestrians

4.4.1. Functional preconditions for (acceptable) safe mobility of people with disabilities with respect to the physical environment

The physical environment should not have obstacles that prevent or make moving in space difficult for persons with disabilities. As a basic principle which has to be sought in shaping the environment, is to create an *unbreakable chain of movement*[10]. By accomplishing this, each person should be able to move normally to any desired destination. The establishment of an unbreakable chain of movement should improve (Figure 10).

It is shown in chart that the intervention has to be made at different levels. In this study, we will stick to the requirements related to the physical environment, which includes: sidewalks, squares, signal, urban furniture, etc. This aspect was largely explored around the world and it was easy to form the norms and standards, legal documents, and manuals that prevent architectural and urban barriers standing in the way of persons with disabilities.

Space requirements for pedestrians with disabilities vary considerably depending on the assistive device used. Spaces designed to accommodate wheelchair users are generally considered functional and advantageous for most people. Figure 11 illustrates the spatial dimensions needed for a wheelchair user, a person with crutches, and a sight-impaired person using the cane.

Keeping in mind the possibility of having a temporary handicap, an environment without barriers is very important for everyone.

In fact, it is estimated that over a quarter of the population in Europe face mobility problems on a daily basis. In this way, a barrier-free environment is important for a large group of society, including:

[10] **The unbreakable chain of movement** entails that a person with any type of disability can move freely within their home and go from their bed to town to any building or space they choose by any means of transport and return home without facing barriers or being exhausted. (Sestranetz & Adams, 2006)

- *People with temporary impairments*
- *People with disabilities*
- *Elderly people*
- *Families or persons with small children*
- *Pregnant women*

In the region, stakeholders are becoming more aware of the importance of supporting diversity. With the ageing of society and the increasing diversity throughout Europe, it is essential for authorities to recognize the importance of building a more inclusive society.
Therefore, a barrier-free environment can no longer be seen as affecting only a minority group but instead policy makers, designers, planners and architects should see it as a way of accommodating a diversity of performance. Facilitating the free movement of this large population group with mobility problems including people with disabilities requires widespread changes in the built environment making all spaces accessible and usable for all ages and abilities such that it contributes to the establishment an unbreakable chain of movement. (European Commission, 2003)

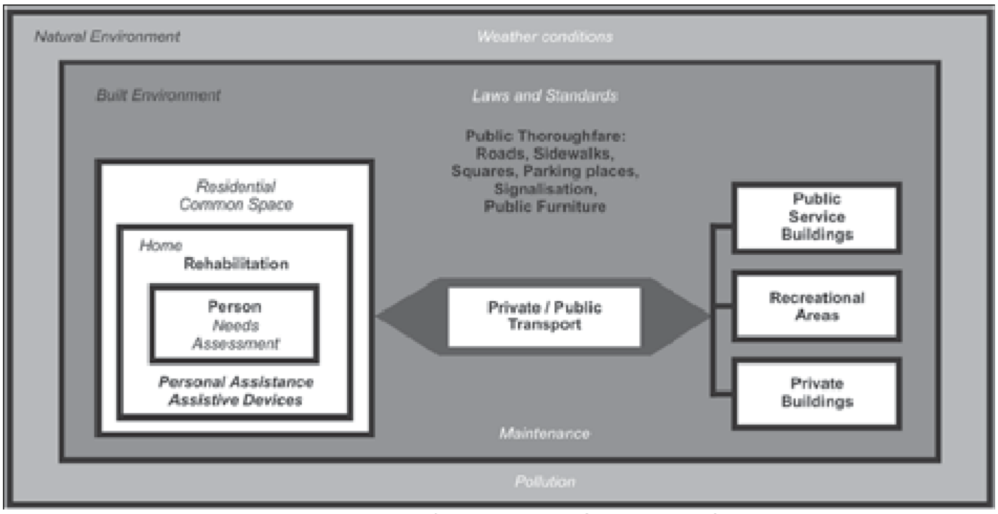


Figure 10 The unbreakable chain of movement (Sestranetz & Adams, 2006, str. 17)

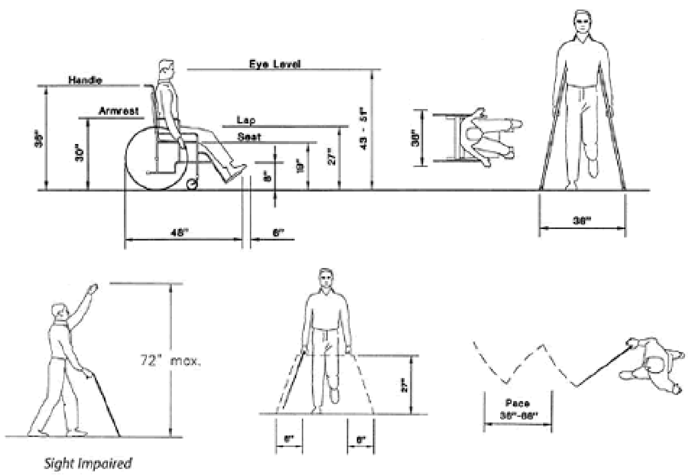


Figure 11 Federal Highway Administration. „Pedestrian Characteristic.“ U. S. Department of Transportation. 2001. and Pedestrian Facilities Guidebook

4.4.2. Functional preconditions for (acceptable) safe mobility of people with disabilities with respect to the social environment

Concept of the unbreakable chain of movement is based on the concept of social inclusion of people with different disabilities. The society will enable the realization of the unbreakable chain of movement for persons with disabilities, providing an adequate legislative framework that would include the following major elements:

- Continuous of movement requires not only a barrier-free environment but also proper support services such as personal assistance, assistive devices and sign language interpretation services in order to ensure that people requiring more specialized services have access to them so they can be more independent;
- Legislative framework including standards, laws and by-laws and implementation mechanisms:
  - Anti-discrimination legislation on disability
  - Laws on construction, urban planning, and transportation and strong measures for their enforcement
  - Accessibility standards in public procurement legal frameworks
  - Regulatory mechanisms for social services at the community level
- Accessibility planning:
  - National disability action plans with clear accessibility directives
  - Budgets allocated to accessibility planning for both existing and new buildings
  - Responsible government bodies established for the implementation of accessibility plans
- Participatory processes are vital for urban planning, transportation and construction planning in which organizations of people with disabilities are involved in the planning process
- Organization of Universal Design and Accessibility Standard trainings for architects, builders, engineers and urban planners. (Sestranetz & Adams, 2006)

4.4.3. Functional preconditions for (acceptable) safe mobility of people with disabilities with respect to transportation access

The principle of the unbreakable chain of movement, under its fifth element, implies that the transport must be accessible as well as the locations where different forms of transport intercept. The type of disability largely determines the preconditions for the availability to other forms of transport. Not fulfilling these preconditions may affect the general social attitude regarding the needs and quality of life of persons with disabilities.

4.4.4. Consequences of limitations and functional impairments of people with handicap

People with disabilities belong to all the previously mentioned age groups, have different levels of education, religious and racial affiliation and can live in different places. According to the facts mentioned the reasons why people with disabilities travel may be different and can vary significantly depending on the subcategory that you are analyzing in a particular situation.

The main reasons of travel can be travel for business or education, travel for social and entertainment activities, travel to perform tasks related to household income and travel for the health services. (Penford, Cleghorn, Creegan, Neil, & Webster, 2008)

Similar to the old people, for fulfilling their needs, persons with disabilities must navigate to a specific destination such as a nearby city centre or a larger city, the local environment, periphery or going to another city, the site located at the other end of the country or abroad. However, according to the type of disability and the destination for which the purpose is associated with, the travel planning is an important part of the process and requires possession of a large number of information. Decisive factors that affect planning of persons with disabilities are the level of spontaneity and flexibility in planning trips and the travel, the provision of accessible information, and the level of confidence when travelling.

Walking, as a mode of transport among destinations is determined by distance and as a key factor will be the level of equipment and arranging the physical environment that provides safe and affordable movement of people with disabilities. They consider trips in which we use other transport modes, and include certain distance that is necessary to acquire walking.

The main reasons and barriers for walking of people with handicap are presented in Table 13.

Table 13 Reasons and barriers for walking of people with handicap

Mode of transport	Psychological/emotional	Practical/functional	Economic
Walking (+)	Purpose Lesure activity Socialisation	Quick local trips	No cost
Walking (-)	Low confidence Fear of crime Fear of injury	Poor weather Limited distances Health conditions Low income	

Tactical level of decision-making is determined by factors related to continuity of movement, the possibility of safe street and intersection crossing, as well as safe movement. This level is mostly determined by the characteristics of the environment, such as the topography, the existence of size-adjusted footpaths, and availability of the equipment adjusted to persons with disabilities. It is necessary that the information and signals are available, which serve people with different types of disability (people with sensory disabilities, persons with mental disabilities, etc.).

At the operational level, the decisive factors for the decisions in movement are the specifics of persons related to different types of disabilities. This level of decision-making is related to the specific characteristics of movement (walking, standing, stepping, etc.) and the level of possible damage will be the decisive factor for the selection of pedestrian movement as well as of the forms of transport. In addition, if a person uses a tool in movement, the level of available equipment in the environment will be another important factor in making this decision. When it comes to travelling in situations that are more complex, and since they require changing different forms of transport, the decision will be made according to the possibilities of entering and exiting the other transportation means, and the possibility of waiting undisturbed in places where the changes of transport are carried out. The possibility to communicate with staff who manages transportation means, and the level of assistance that they can provide when people with disabilities are involved in different forms of traffic are also important.

Factors that influence different levels of decisions are shown in following Table 14.

Table 14 Factors that will influence different levels of decision making

Mode of transport	Strategic	Tactical	Operational
Walking	Leisure activity No cost Quick local trips Distances Equipment and arranging the physical environment	Fear of crime Fear from other traffic users Health conditions Characteristic of the environment	Characteristics of movement Health conditions Poor weather

4.5. Other groups

Other groups can be extracted from some other groups of pedestrians, but their size and characteristics are not extensive enough to be separated. Possible parameters vary regarding the professional commitment, habits, place of origin and living, etc. However, their differentiation would overlap mentioned groups, so that some of their characteristics can be represented.

Instead of physic, psychomotor, sensory and cognitive abilities, we can analyze the action performed during walking by some studies done in USA. (NYC Department of City Planning, 2006) From this, we can distinguish smokers, pet owners, people who consume food in motion, people who listen to music or talk on a mobile phone while moving. Given the kind of action performed during the walk, some of the abilities may be limited (less attention when talking on a phone, limited hearing when listening to music, reduced speed of walking during the consumption of food, etc.).

In this study, these pedestrians will not be singled out as a distinct group. However, it is recommended that some of the future researches consider the characteristics of those pedestrians who perform another action while walking.

5. Conclusion

This paper presents the main results and conclusions related to the research of functional abilities of humans and identifications of specific groups of pedestrians. The abilities are individual characteristics that make someone perform certain actions and they can be divided into four groups: physical, psychomotor, sensory and cognitive abilities. *Physical abilities* are those individual skills that include strength, endurance, flexibility, balance and coordination. *Psychomotor abilities* are skills that affect the ability to manipulate and control objects. *Sensory abilities* are abilities that affect the visual, sound and speech perception. *Cognitive abilities* are the abilities that affect the acquisition and use of knowledge during solving certain problems. Having in mind the identified groups of abilities, there were analyzed the characteristics and abilities of pedestrians that influence pedestrian movement, and segments and elements of pedestrian traffic and infrastructure on which it can be reflected.

Following noticing the abilities that are necessary for walking, the physical environment, social environment and transportation access, as preconditions for the safe mobility of pedestrians, are considered. Those preconditions affect the decisions on all three strategic levels (operational, tactical and strategic) regarding the movement of a pedestrian. In addition, listed preconditions do not act independently, but as a system.

Based on abilities and characteristics, the specific groups of pedestrians and their general characteristics are identified and described (children, adults, elderly and persons with disabilities). The logic of classification is established on principle that the first grouping is based on the main characteristics of pedestrians. Next substantiation and analysis follows to document preconditions (physical environment, social environment and transportation access) for the safe mobility of pedestrians that belong to the defined category. Besides the selected main groups, some groups that are classified as “others” are also mentioned in this article, but these are not dealt with in detail. This needs to be done in a separate study.

The consequences of limitations and functional impairments of different groups of pedestrians are explored on the basis of established three strategic levels of decision making (operational, tactical and strategic). Clearly the identified groups show a specific behaviour related to their abilities, and it appears that on each decision level there are also great differences between the groups. In this context we conclude that it is necessary to ensure barrier free environments (physical, social, transportation, etc.) in which people can move and sojourn freely and independently, without being restricted by limited abilities.

At the end of the subsections main reasons and barriers for walking for people belonging to the different groups are were identified. Also the factors that will influence different levels of decision making (strategic, tactical and operational) are reported.

With regard to walking and sojourning in public space the main aim should be to make sure that walking becomes a choice for all (C4A). In this respect it is vital that policy makers and designers have knowledge about behavioural abilities of the different groups of pedestrians that need to be supported. They should be aware of the consequences of the different characteristics of these individuals and deal with them properly.

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The safety of pedestrian crossing.

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'No problem can be solved from the same level of consciousness that created it.'
Albert Einstein

Summary

More than half of all severe traffic accidents in which pedestrians or cyclists are involved, occur during road crossing. In this chapter insights, based on previous studies and literature, concerning requirements for safe and comfortable crossing facilities are discussed.

In order to develop notions of needs, abilities and motives, different pedestrian groups with similar physical and cognitive characteristics have to be defined. Research has shown that children under 11 and elderly above 75 years old are the most vulnerable pedestrian groups. Based on the development of cognitive capacities, such as attention, inhibition, planning and risk perception, in children a subdivision of four different age groups is proposed: children from 0 to 4 years old, children from 5 to 7 years old, children from 8 to 12 years old and children from 13 to 17 years old. Besides children, also people aged over 65 represent a vulnerable group of pedestrians, due to physical as well as functional constraints. In general elderly have a reduced physical fitness and -resistance, lower workload capacity and a reduced peripheral field of vision. Another group of pedestrians that deserve special attention are handicapped road users, either being physically or cognitively disabled. Whereas healthy adults are the least vulnerable, suboptimal situations in environmental design, crossing facilities and specific traffic circumstances may still create conditions that exceed the limits of normal human functioning.

Irrespective of the specific pedestrian group, good walking conditions are required to have people at least consider the option of walking. With respect to road crossing, it is especially relevant whether a crossing facility is safe and inviting (Convivial), comprehensible (Conspicuous) and whether facilities are sufficient in number and quality (Convenient). Since crossing involves a complex set of actions, providing pedestrians with crossing facilities can

reduce cognitive load. In general an unsignalised crossing is more dangerous than a crossing that is signalised with traffic lights. The presence of other crossing facilities, such as a median or a zebra can help to increase (feelings of) safety. Whether safety is actually increased by these measures, is dependent on many factors such as the facility's location, its visibility and traffic density. Besides general requirements, specific pedestrian groups have distinct preferences and needs. For example, a green light period should be adapted to the walking speed of older people or physically disabled people in order to make them feel safer. For younger people a relative short green light period causes impatience and therefore a higher risk potential. Therefore, in designing facilities for pedestrians, it is valuable to investigate which people will probably be mostly present.

In the final part of this chapter, conflict patterns and measures to reduce conflicts and accident severity are discussed. The most important conflict partner of the pedestrian is the car (65%). In the Netherlands 84% of all pedestrian accidents with severe injuries occur within urban areas. Whereas in an absolute sense, most pedestrian crashes occur in daylight, crash rates are higher during the night, when controlled for exposure and vehicle flow. Measures to reduce conflicts can concern measures on the behavioural level (education, public campaigns) as well as changes in traffic rules (speed limits), infrastructural design (separation of road users differing in mass, speed and direction and vehicle design (pedestrian-friendly car fronts, side-underrun-protection).

Based on above findings it can be concluded that the development of safe and comfortable crossing facilities first of all requires insights in pedestrian needs and abilities. Moreover, the specific needs of specific groups of pedestrians have to be taken into account. The benefit of such an approach is two-fold. To start with, gaining insight in these aspects makes traffic-engineers more conscious of the necessity to systematically meet pedestrian needs in our traffic system, in order to develop a safe and convenient pedestrian environment. Secondly, it provides us with concrete knowledge on which factors at which locations have to be taken into account when designing crossing facilities.

1. Crossing behaviour – the main problem

1.1. The challenge(s)

More than half of all severe traffic accidents in which pedestrians or cyclists are involved occur during road crossing (SWOV, 2006). In order to make crossing safer, it is important to define pedestrians' abilities and user needs. What are (different groups) of people able to do and what motives do they have as a pedestrian? This can eventually lead to more pedestrian friendly environmental planning and design. This is especially important since the value of systematically meeting pedestrian needs is often not yet recognized, whereas qualities or deficiencies of the physical environment are more intensively experienced by pedestrians than by other road users (Methorst, 2006).

1.2. Defining groups

Pedestrians vary widely in their physical and cognitive abilities. In order to gain insight in the requirements for safe and comfortable facilities for all, groups of pedestrians with similar physical and cognitive characteristics have to be defined.

Recently, it has been shown that children under 11 and elderly people above 75 years old are the most vulnerable groups of pedestrians (SWOV Factsheet, 2006). Age is an important criteria based on which pedestrian groups can be defined. Based on the developmental literature a subdivision in children of four different age groups is proposed in the present report: children from 0 to 4 years old, children from 5 to 7 years old, children from 8 to 12 years old and children from 13 to 17 years old (SWOV Factsheet, 2006; Johansson & Leden, 2009; Methorst, 2003). The youngest group consists of children that are not able to participate safely in traffic on their own. Children in this age-category have not yet developed a proper ‘theory of mind’, that is pre-school children have a limited awareness of other’s perceptions and intentions. If young children can see a person, for example a car driver, they tend to automatically assume that the other person can see them as well (Johansson & Leden, 2009). Moreover, risk awareness and attentional abilities are still low. Therefore, the most important factor for this group is the risk awareness of the parents; they need to stay around (Rosenbloom, Eliyahu & Nemrodov, 2007; Dunbar, Hill & Lewis, 2002). The second group, children from 5 to 7 years old, consists of children that are developing very fast in many ways. Whereas in some areas the child develops a grasp of logical concepts, they still show a tendency to focus attention on one thing while ignoring others. Despite an increased awareness of traffic in general, their risk awareness is not sufficient yet (Dunbar, Hill & Lewis, 2001 & 2002). Therefore they must rely on an adult, whose role is important for the child in learning the traffic rules. Mainly their capability of assessing what other road users will do is insufficient. These children often mostly walk in their own neighbourhood and are still mostly accompanied by an adult (Rosenbloom et al., 2007). This latter fact is what distinguishes them from the third group. This third group consists of children that are starting to participate in traffic independently. Despite between-individual variation, in general an important transition age concerning cognitive development is around 7 years of age, related to the development of so-called executive functions. One such cognitive function is inhibition. This enables a child to inhibit thoughts and actions in the service of other (more urgent) behaviours. Also planning abilities develop around this age. The further development of these high-level cognitive abilities in children between 8 and 12 years old enables them to participate more independently in traffic. Crossing the street is however a complex task, and children have not fully developed all the required abilities before the age of 11 or 12 (Johansson & Leden, 2009). Children this young age still have problems with assessing speed, direction and distance of moving vehicles. They tend to adopt the same distance gap when crossing the street, irrespective of the vehicle’s speed. (Johansson & Leden, 2009). Children in the last group, with ages ranging from 13 to 17 years old, mostly travel independently. These children are vulnerable especially because they are susceptible for the opinions of their peers. Of all groups, they are most likely to imitate other road users, especially classmates. Consequently, the main reason for their vulnerability are attitudes and social motivations.

Also elderly people (65+) represent a vulnerable group of pedestrians, due to physical as well as functional constraints (Holland & Hill, 2007; Bernhoft & Carstensen, 2008). The fact that pedestrians are unprotected especially provides a disadvantage for the elderly because with age, bones get more brittle and elasticity of the soft tissues and muscle strength decline. This causes elderly in general being more severely injured than the young in crashes with equal collision energy (Wegman & Aarts, 2006). Whereas high variability may exist between people of the same age, in general elderly have a reduced physical fitness, resulting in earlier fatigue, lower walking speeds and reduced balance and flexibility. Moreover, lower workload capacity and a reduced peripheral field of vision, leading for example to problems in estimating speed of other traffic, induce their vulnerability as a pedestrian.

A different group of vulnerable road users are disabled road users. Disabilities can be divided into three different categories: mobility, sensory, and cognitive disabilities. Especially people using wheelchairs need more physical space in order to manoeuvre properly. Moreover, they are generally slower, have a smaller overview and are less visible for other road users. For people with visual, auditory or mental impairments also the way in which information is conveyed (modality, simplicity) at a crossing is of vital importance (see also the next paragraph).

1.3. Crossing facilities

Local and national governments promote walking because more transport by foot can benefit the environment and improves personal health. However, to increase the amount of walking, personal and environmental benefits are not sufficient. In order to have people consider the option of walking instead of other modes of transport, good walking conditions are required. 'Walkability' of a place can be characterized by the 5 C's (Transport for London, 2005), that is Connected, Comfortable, Convivial, Conspicuous, and Convenient. With respect to road crossing, the final three factors are especially relevant. Convivial means that walking facilities should be safe and inviting, that is pleasant to use. Conspicuousness relates to the important aspect of comprehensibility of walking facilities; crossing facilities should be clear and legible. Convenience concerns the degree to which crossing facilities fit the usability needs in terms of number and quality. Based on these criteria and on what we know about the functional abilities of different pedestrian groups, requirements for safe and convenient crossing facilities can be developed. The design of pedestrian (crossing) facilities should, whenever possible, be aimed at pedestrians with the lowest level of ability, or adaptable to specific (dis)abilities (e.g. dynamic traffic light duration) in order to ensure pleasant and safe conditions for all pedestrians.

Crossing the street involves a complex set of actions. The act of crossing requires a correct judgement of traffic speed and movement, traffic gaps and estimates of the time needed to cross. Providing pedestrians with crossing facilities can reduce this cognitive load, and consequently increase convenience and (sense) of safety, when crossing a road. Pedestrian crossings signalised with traffic lights are often used on busy roads with lots of traffic. The speed limit there for the motorised traffic is often higher than with unsignalised crossings (the latter ones are mostly in urban areas). Even though these types of intersections are signalised, 40% of all crashes involving pedestrians occur there (Tiwari, Mohan & Fazio, 1998). Waiting for the green light. is something pedestrians do not like very much. As a consequence, many violations occur that of course raise the risk of an accident (Bernhoft & Carstensen, 2008; Medina, Benekohal & Wang, 2007). In this case, decreasing the waiting times for pedestrians could help. This can be done for example by giving priority to pedestrians (e.g. by providing them the green light more often), but also by reducing the crossing distance and by keeping the traffic light green longer for pedestrians (SWOV Factsheet, 2006).

An unsignalised crossing is often more dangerous than a crossing that is signalised with traffic lights. The pedestrian needs to trust his own perception and risk awareness to get to the other side of the road safely. There are differences in the degree of safety nevertheless. An unsignalised crossing with a median (so pedestrians can cross the street in two phases) is less dangerous than a crossing without a median (SWOV Factsheet 2005). After all, in this first case, the pedestrian has the possibility to concentrate on the oncoming traffic twice. However, when pedestrians have no priority on a crossing, the situation is still not safe enough. A zebra crossing, for example, is meant to help pedestrians in crossing the street faster and safer; the oncoming traffic is expected to wait. The mere presence of a crossing facility (such as zebra markings) does however not automatically imply increased safety. Reality learns that many pedestrians often do not use the zebra crossings and that drivers do not always stop for pedestrians that do use them (SWOV Factsheet, 2006). One reason could be that pedestrians do not trust the oncoming traffic enough and consider these zebra crossings and crossings without priority equally (un)safe. For this reason, walking a bit further to use a zebra crossing is not worth the effort for pedestrians. Another reason can be the visibility of zebra crossings, for pedestrians as well as car drivers. Zegeer, Stewart, Huang & Lagerwey (2001) investigated pedestrian crashes at 1.000 marked crosswalks and 1.000 matched unmarked comparison sites. None of the sites in this study had a traffic signal or stop sign. The authors found that in case 24 hour traffic volume was less then 10.000 vehicles, safety levels were equal for locations with crossing facilities (markings, such as a zebra) and without any facilities. However, when traffic volume was larger, locations without any marking turned out to be safer. This might have to do with the fact that in dense traffic, car-drivers do not notice the markings. Also other research has shown that unmarked crosswalks on multilane roads with high average daily traffic scores are safer (i.e. less crashes) than marked crosswalks on the same road types (Shurbutt, van Houten & Turner, 2007).

As such it is very important to consider the context, such as traffic density, before implementing specific crossing facilities. (Sense of) safety is very important in this respect. A measure that is already used to increase pedestrian safety is to place the zebra crossings on or just after a plateau. By doing so, the oncoming traffic is forced to reduce speed, which also draws the attention of the driver (SWOV Factsheet, 2006). The latter consequence might lead to a higher chance of perception of pedestrians who are about to cross. Another important issue is the extent to which crossing facilities are recognizable for drivers and pedestrians When crossings in general are made more uniform and recognisable, this will also increase safety (SWOV Factsheet, 2005).. Different designs and layouts may cause a lack of clarity which can lead to reduced understanding and consequently unsafe behaviour. Pedestrian crossings should therefore be more standardized and should be on places where the sight for the driver is good (e.g. not directly after a curve). Based on a study into safety related characteristics of 121 crossing facilities in the Netherlands, De Langen (2003) concluded that crossing facilities in the Netherlands lack uniformity. Nevertheless, even with zebra-marks or signals, crossing a road with six lanes will never feel safe and comfortable. In such settings, pedestrian paths below or above street level would be good alternatives

Besides the average pedestrian, specific pedestrian groups have different abilities and consequently have distinct preferences and needs. Children younger than 11-12 years have not yet developed all the necessary cognitive abilities and their risk awareness is insufficient in order to cross a road safely on their own. Ideally, at locations with many young road users, such as schools or playgrounds, motorized traffic has to be kept out as much as possible. In case this can not be realized safe circumstances have to be created in which children are assisted in crossing the road by school crossing patrols and car drivers are especially aware of the fact that children can dart out into the street. Crossings and signalised intersections are often better appreciated by older than by younger pedestrians (Bernhoft & Carstensen, 2008). Younger pedestrians do not necessarily notice when these facilities are missing, they tend to care more about moving fast and directly in traffic and do not like to wait or stop. Especially younger men tend to neglect the use of pedestrian facilities (Kim et al., 2007). Older pedestrians, on the other hand, often experience doubts about their own abilities, which in turn causes them to be more cautious in specific traffic situations (Holland & Hill, 2007; Bernhoft & Carstensen, 2008). The extent to which they experience the need to be safe and have respect for the law is therefore higher than for younger pedestrians. That is why they often plan their route through town according to the presence of pedestrian facilities. Practically, this means that in designing crossing facilities for pedestrians it has to be investigated which people will probably be present. In dense traffic, light signals are appreciated especially by older people because they experience difficulties in perceiving when a gap is sufficient enough for them to cross the street. One other, very important topic is the green light period. This period should be adapted to the walking speed of older people or physically disabled people in order to make them feel safer (Bernhoft & Carstensen, 2008). For the same reason crossing distances should not be too long. Otherwise, they might feel as if they have to hurry to be able to get to the other side of the road in time, which might cause unsafe behaviour (i.e. higher walking speed, causing more risk of falling). For younger pedestrians, a short green period causes impatience and therefore a higher risk potential (Bernhoft & Carstensen, 2008). In the Dutch city of Tilburg, a study was performed to investigate what factors are causing the percept of “short green time” (Godefrooij, 2008). What was found is that for many pedestrians their feeling of danger causes them to indicate perceived green times as too short. It has been shown that many people are only able to cross the street to the centre median strip in the available green time. The fact that the median strip is narrow and unsafe is shown to be an important factor for the percept of short green time. Furthermore, people are not always sure how much time is left for them to cross before the cars will start driving when the light has become red during crossing. A new type of traffic light has been introduced in Tilburg, which displays both waiting time and crossing time. This approach reduces the uncertainty of pedestrians to a great extent.

Other important issues concerning crossing facilities are the spatial layout as well as the walking surface. The walking surface should be even to prevent falling for older or physically disabled people and make it more convenient for younger people as well, since they (at least to some extent) can walk faster on an even surface than on an uneven surface (Bernhoft & Carstensen, 2008; SWOV Factsheet, 2005). Also the spaces in which pedestrians can comfortably manoeuvre differ. A width of 1 m is adequate for people with ambulant (using crutches or a walking frame) disabilities whereas a wheelchair requires at least a clear width of 1.2 metres. Also stable, even surfaces with no rapid change in slope are required for mobility impaired people as well as for visually impaired pedestrians.

Besides the architecture, the information conveyed to pedestrians at pedestrian crossings should be clear. Ideally, the design of a crossing should be intuitive, not requiring too much extra information to explain its use. However in some cases, providing extra information is necessary. In these cases information has to be simple, universal and very well visible. For people suffering from visual impairments should be provided with tactile cues or signs, whereas clear visual signs and long sight distances free of visual obstructions are very helpful for people suffering from hearing impairments. For mentally disabled pedestrians clear pictures, symbols and colours, instead of words, can be used to convey information.

2. Conflict and accident pattern

2.1. General overview

In the Netherlands the most important collision partner of the pedestrian is the car (65%). Whereas large trucks, busses and trains are involved in few accidents with pedestrians, they have a relatively large share in the number severely injured pedestrians who do not survive (SWOV Factsheet, 2006). Pedestrian safety is, as in other countries, determined by the amount of motorized traffic, which is still growing every year. Pedestrians are very vulnerable simply because they are without vehicle and are thus lacking a shell to protect them. For example, in the EU countries pedestrians are on average 6.7 times more likely to be killed in a traffic accident than vehicle occupants, whereas motor-vehicle accidents with pedestrians (and bicyclists) constitute a relative small proportion of the total amount of crashes (Shinar, 2007). In addition to the lack of protection, pedestrians are vulnerable because of large mass and speed differences with other road-users. Most accidents take place when crossing a street. The time pedestrians spend on crossing streets might therefore be considered as a valuable measure when defining a pedestrian risk factor (Shinar, 2007).

2.2. Location and time of conflicts

In the Netherlands, research has shown that 84% of all pedestrian accidents with severe injuries occur within urban areas, due to a large road-user density within these areas which bring about an increased likelihood of a conflict (SWOV, 2006).

Within these urban regions specific locations can be considered as especially risky regarding pedestrian accidents. Locations with vulnerable road users (such as schools or locations where many elderly cross the street) are areas which require special attention. Also specific hours of the day, on which traffic intensity is high or visibility is reduced, might be more risky for pedestrians. Whereas in an absolute sense most pedestrian crashes occur in daylight, crash rates are higher during the night when controlled for exposure and vehicle flow (Shinar, 2007). Low visibility of pedestrians during night time appears to be the most important cause. Probably for the same reason accident rates differ between seasons. For example in the US, September through January, months with typically fewer daylight hours and more bad weather conditions, show the highest numbers of pedestrians fatalities. Fatal accidents with children are greatest in May-July, probably related to in increase in outdoor activity during the summer. Age and time of day may also interact when considering pedestrian crash rates. In some age groups most accidents happen on specific times of day. For example in the Netherlands data show that within the group of young pedestrians (0 -14 yrs) accidents which lead to severe injuries mostly find place between 16.00 and 18.00 hrs (SWOV, 2006). These findings may relate to playing behaviour during these after-school hours. According to analyses by Sentinella and Keigan (2005) most pedestrian accidents in which children are involved occur when children are playing rather than on the way between home and school. Findings indicate that young children are unable to properly focus on traffic while involved in other (playing) behaviour (Shinar, 2007).

2.3. Measures to reduce conflicts (severity)

Infrastructure and separation

Besides design considerations of crossing facilities, measures to make pedestrian road crossing more agreeable and safe can also concern measures on the behavioural level as well as changes in traffic rules and infrastructural- and vehicle design. A very effective measure in this respect is the separation of road users who differ in mass, speed and direction, which can prevent severe collisions with vulnerable road users.

Speed limits

In case it is impossible to separate different road-users, speed limits should be introduced which reduce the impact of potential collisions. International research has shown that driving speeds higher than 30 km/hr drastically increase the probability of a pedestrian being killed in case of a collision (SWOV, 2008). Introducing speed limits does not automatically imply that drivers stick to these limits. Other measures, such as speed bumps, could ‘force’ drivers to adjust their speed.

Vehicle design

Another way to prevent or reduce the impact of accidents is to introduce pedestrian-friendly car fronts, that is taking into account in car design the location at which pedestrians hit cars (Wegman & Aarts, 2005) as well as the removal of sharp and inflexible parts (SWOV, 2006), in order to reduce the severity of pedestrian injuries in case of an collision. Also large vehicles should be equipped with side-underrun-protection as well as good side and rear view.

Driver and pedestrian education

Besides environmental- and vehicle design an important factor in pedestrian-vehicle conflicts is of course both driver and pedestrian behaviour in traffic. During driving lessons aspirant drivers should be informed and educated on safe driving behaviour, also specifically in relation to pedestrians. Also public campaigns can aim at making drivers as well as pedestrians more aware of safe and unsafe behaviour. Behavioural interventions concerning pedestrians are especially targeted at children. Children up to 12 years old are likely to be involved in accidents because they suddenly dart into the street. In general children younger than 12 do not have yet adequate crossing behaviour. Despite the fact that from around ten years old they do already know the safety rules, they are often not able to apply these rules in daily practice (Shinar, 2007). It is therefore important to provide age-appropriate education and practice on schools. For this age group also school crossing patrols might be an effective measure to increase safety. Also parents should be encouraged to educate their children on safe crossing behaviour. Research has however shown that children show more dangerous crossing behaviour when accompanied by an adult than when alone or with other children. An explanation might be that they simply trust on the adult and therefore do not pay much attention to the road (Rosenbloom et al., 2007). Older teenagers generally do have safe crossing skills, but they do not always apply them. This is suggested to be related to a tendency to increased risk seeking and insufficient self-regulation in adolescents (Steinberg, 2004). Therefore education for this group of children should not be focused at crossing skills but at learning about the consequences of their behaviour.

The findings and insights described in this chapter show that the development of safe and comfortable crossing facilities first of all requires insights in pedestrian abilities. Before defining a crossing facility in terms of the environmental requirements, the capacities and limitations of its users have to be taken into account. Consecutively, in terms of Conviviality and Convenience, the specific needs of different groups of pedestrians have to be considered. The benefit of such an approach is two-fold. To start with, gaining insight in these aspects makes traffic-engineers more conscious of the necessity to systematically meet pedestrian needs in our traffic system, in order to develop a safe and convenient pedestrian environment. Secondly, it provides us with concrete knowledge on which factors at which locations have to be taken into account when designing crossing facilities.

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Walking accessibility of public transport modes.

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Summary

1. Introduction

Our goal is to make walking more popular within the city, not only because it is healthy, but also because it can help to solve traffic problems on the overcrowded streets. So, recreational trips are nice, but the most important is to force people walking during the purpose trips: to work, school, university, etc. These obligatory journeys are made usually at least twice a day – unfortunately by car in a great extent. As asking people to go on foot several kilometres is unrealistic, let these longer journeys be made using public transport, where walking covers a substantial part of the trip chain. An important issue is also persuading people for using public transport modes in journeys to the restaurant or club where they drink alcohol.

Walking and cycling are the most environmental friendly modes of transport. Here we are dealing with walking, as it is more popular and is an element of each journey. When the distance is too long for a walk you have to go to the parked car or to the public transport stop. In sustainable city we would like to prefer using public transport instead of car. The best way for achieving it is to make public transport more attractive for travellers. Decisions on changing the drivers' behaviour will be easier when some restrictions for the car use will be implemented.

People will choose public transport more often when the walking conditions will be better. The cities have to do more for making the city environment more pedestrian friendly. In this paper we will concentrate on the method for measuring the attractiveness and accessibility of public transport stops.

2. Public transport attractiveness

The most popular public transport modes in European cities are bus, tram and underground. Public transport mode is attractive when it offers:

- High speed
- High frequency
- High comfort.

The highest speed is offered by the underground. Lack of collisions with the surface traffic is the main reason why the average travel speed in underground is usually about 35 km/h. The speed is slightly lower in the city centre surrounding where the distances between stations are lower.

The revitalization of tram systems can be observed in several cities. In some cities the new tram routes on separated right-of-way, with modern cars and preferences on street junctions can offer quite a good speed. The speed is much lower when the tram network is old and the trams use the traffic lane with cars. The average tram speed can be estimated on the level of 18 km/h.

Bus is the most popular public transport mode. The average travel speed is about 14 km/h and mostly depends on traffic conditions. The speed is higher on separated bus lanes where buses are not mixed with regular traffic. Usually the speed is much higher in suburban areas where the traffic density is lower and distances between bus stops are longer.

The highest frequency – on average every 3 minutes – is typical for the underground. Here the waiting time on a platform is really very short. This is a big difference in comparison with trams and buses, where frequency is about 15 minutes. When the frequency is lower passengers usually follow the time table. The problem is that because of traffic jams buses are quite often late and passengers have to wait at the bus stop longer.

Both speed and frequency influence the travel time – the most important factor for making decision on travel mode. People choose public transport more often when they find that the total travel time from door to door (including walking time) is shorter than travelling by car.

High travel comfort means that vehicles are not overcrowded and there are sitting places available. High capacity of public transport mode usually makes that the travel comfort is better. The highest capacity has an underground and the capacity of trams is higher than in case of buses. Also the shelters on public transport stops should protect from poor weather conditions and be facilitated with the benches.

The importance for passengers describes the public transport stop rank value (PTR). It depends on all factors mentioned above. In case of underground it is higher when the station serves more than one line. In case of tram and bus stops more attractive for passengers are those which serve more vehicles per hour. The higher number of buses or trams means that the stop serves more lines, what gives possibility for choosing the most suitable destination and route. The rank value of public transport stops is shown below.

PTR for the underground station is:

- **4 points** for the station with one underground line
- **6 points** for the station which serves two or more underground lines.

PTR for the tram stop is:

- **2 points** for the tram stop which serves more than 20 trains per hour
- **1.5 points** for 10-20 trains/h
- **1 point** for less than 10 trains/h.

PTR for the bus stop is:

- 2 points for the bus stop which serves more than 40 buses per hour
- 1.5 points for 10-40 buses/h
- 1 point for less than 10 buses/h.

3. Walking distance to public transport stop

Attractiveness of public transport stop for passengers also highly depends on the walking distance from the travel origin.

An average walking distance to the public transport stop within the city district can be short when:

- Density of public transport routes network is high
- Land use is intensive
- Detour factor for walking is low.

Density of public transport routes network can be measured in the lengths of the bus, tram and underground routes per 1 square kilometre of an analyzed area. The routes density must be economically justified. It means that the number of potential passengers have to be big enough. Only very intensive land use will allow to construct an underground. In such a case the underground line can be even supported by the tram and bus lines. When the density of population and work places is low there is only a chance for a bus line.

The shortest way is when you can go from your home entrance to the public transport stop following the straight line. In practice such a situation never exist. Usually you find on your way a lot of obstacles: buildings, fences, etc. You should follow existing pedestrian ways which have to connect many destinations (to the next buildings, shops and services), not only to the nearest bus stop. The public transport stop is closer your home when the detour factor is the lowest and your way is as close as possible to the straight line.

There are three zones of acceptable walking distance (WD measured in a straight line) to the public transport stop:

- ✓ I zone, where the distance is the lowest, values 3 points
- ✓ II zone gives 2 points
- ✓ III zone, with the longest acceptable walking distance, values 1 point.

The magnitude of distance zones depends on the public transport mode attractiveness. Usually people agree to walk longer to the underground than to the bus stop.

The density of bus routes is the highest and acceptable walking distances are the lowest: up to 150 meters for the first zone, 300 for the second and up to 450 meters for the third zone. For the tram routes acceptable distances are: 200, 400 and 600 meters. In case of underground an area of influence is the biggest: I zone is up to 300 m, II zone up to 600 m and the III zone up to 900 meters.

Public transport stop attractiveness for pedestrians depends at least on two elements explained above: walking distance and the public transport stop rank, and can be measured using the following formula:

A’ (PT/Ped) = PTR x WD

Where:

- **A’ (PT/Ped)** – attractiveness of public transport stop for pedestrians
- **PTR** – public transport rank factor
- **WD** – walking distance factor.

For the more detailed analyses an additional factor should be taken into consideration: the walking comfort – WC.

4. Walking comfort validation

In **purpose trips** the most important is that the walk should be **short, pleasant and safe**.

To be more precise, what is indispensable for validation, we can assume that the walking comfort (WC) depends on five elements:

- Detour factor in 30%
- Vertical alignment factor in 25%
- Traffic issues in 20%
- Functional issues in 15%
- Environmental issues in 10%.

The best walking comfort is when WC = 100% = 1

Now the formula will be more accurate with the correction taking into account walking comfort:

A (PT/Ped) = PTR x WD x WC

The validation of each walking comfort element is made as follows:

Detour factor

Each 2% of longer walk than along the straight line makes WC lower by 0.01. If detour factor is 60% or more the WC is lower by 0.30.

Example: When a straight distance from the home entrance to public transport stop is 100 m and the walking distance is 120 m, the detour factor is 20%, what makes WC lower by 0.10.

Vertical alignment factor

The sum of all elevations going up in poorer direction should be measured. It is not enough to give only the difference of the level between points A to B or B to A.

Each 1% of upgrade makes WC lower by 0.025. If the sum of elevations is 10% or more of the walking distance, the WC is lower by 0.25.

Example: When the sum of going up elevations (including stairs) on 100 m walk is 5 m, vertical alignment factor is 5% and WC is lower by 0.125.

Traffic factor

The traffic factor makes WC value lower by 0 – 0.20.

The decrease of 0.20 WC value is the lowest when:

- The way is safety (no traffic accidents recorded)
- There is no need to wait on traffic lights and the way do not cross the road with a heavy traffic

- The density of pedestrian traffic is optimal: sidewalks are not overcrowded but some people make the street more interesting and secure
- The pavement is in good state of repair.

Functional factor

The functional factor makes walking comfort value lower by 0 – 0.15.

The decrease of 0.15 WC value is the lowest when:
- The way is lighted at night, well secured (no robbery, etc.) and people feel safe
- Public transport stops are organized close to pedestrian crossings
- There is a clean and interesting (shop windows) surrounding
- There are no obstacles on the sidewalk.

Environmental factor

The environmental factor makes walking comfort value lower by 0 – 0.10.
The decrease of 0.10 walking comfort value is the lowest when there are:
- Clean air
- No traffic noise
- Nice green area
- A part of a sidewalk is under arcades for weather protection.

5. Calculation procedure

Let us analyze the public transport accessibility from the house, where:
- ✓ The distance in a straight line from the house entrance to the underground station is 400 m, what means that the underground stations is located in II zone of accessibility and the walking distance factor value is WD = 2
- ✓ The underground station serves only one line so its rank factor value is PTR = 4

The comfort parameters in a walk to the underground station are as follows:
- The walking distance is 560 m and is 160 m longer than measured in a straight line – the detour factor is 40%. As each 2% of longer walk makes the walking comfort index (WC) lower by 0.01, in this case WC will decrease by 0.20.
- The sum of going up elevations is 5.6 m: it includes 2.0 m of a sidewalk slope and 3.6 m of stairs to the underground station. Escalators leading to the platform are not included in this calculation because they do not make you tired. 5.6 m on a distance of 560 meters is only 1%, what decreases WC by 0.025.
- During last year there were no traffic accidents and pedestrian density is optimal. However, on the way you have to cross one street with traffic lights and a sidewalk is in poor state of repair on a distance of 150 m, what make decrease of WC by 0.06.
- The criminal statistics show that the way is well secured. The entrances to the underground station are well located and there are no obstacles on the sidewalk. There is a lot of interesting shops but the surrounding is quite dirty, what makes decrease of WC by 0.02.
- There is a clean air and the noise level is acceptable. However, the greenery is poor and there are no arcades along the sidewalk, what makes decrease of WC by 0.05.

All these disadvantages influence the walking comfort:

$$\mathbf{WC} = 1 – (0.20 + 0.025 + 0.06 + 0.02 + 0.05) = 1 – 0.355 = \mathbf{0.645}$$

As a result of these calculations we can validate an attractiveness of the nearest underground station (AU) for inhabitants of an analyzed house.

$$AU (PT/Ped) = PTR \times WD \times WC$$

$$\mathbf{AU (PT/Ped) = 4 \times 2 \times 0.645 = 5.16}$$

During process of validation accessibility of public transport stops all transport modes should be taken into consideration. If in an analyzed case in the vicinity of our house there is also the bus stop, we have to repeat the same procedure:

- ✓ The distance in a straight line to the bus stop is 100 m, what means that the bus stop is located in I zone of accessibility and **WD = 3**
- ✓ The bus stops serves 25 buses during pick hour so its rank value is **PTR = 1.5**

The comfort parameters for this short walk are:

- The walking distance is 120 m so the detour factor is 20%, what decreases the WC value by **0.10**
- The sum of going up elevations is 6.0 meters what makes an average upgrade equal 5%. In this case WC is decreased by **0.125**

The detailed analyzes shown that:

- The traffic factor decreases WC value by **0.05**
- The functional factor makes it lower by **0.10**
- The environmental factor decreases WC value by **0.04**.

All disadvantages makes that the walking comfort index is:

$$WC = 1 – (0.10 + 0.125 + 0.05 + 0.10 + 0.04) = 1 – 0.415 = 0.585$$

Now we can validate an attractiveness of the bus stop.

$$\mathbf{AB (PT/Ped) = 1.5 \times 3 \times 0.585 = 2.58}$$

The total attractiveness of analyzed location from the point of view of the walking accessibility of public transport modes is

$$\mathbf{A (PT/Ped) = AU + AB = 5.16 + 2.58 = 7.74}$$

The validation of public transport stops accessibility is a good method for checking and comparing the quality of public transport system and pedestrian ways within city districts. In an analyzed case the value of A (PT/Ped) is relatively high, what is typical for the central area of a big European city.

6. Conclusions

1. Walking is the most sustainable mode of transport and should be promoted in urban and transport planning. For longer journeys within the city people have to be encouraged to use public transport – in particular during obligatory trips to work and schools. In all journeys by public transport modes walking is an important element of a trips chain.

2. Making city environment more pedestrian friendly helps to take decision on decreasing car use and looking for the most suitable public transport connections. The crucial factor for changing drivers' behaviour is a good accessibility of attractive public transport stops.

3. The density of public transport network should provide an acceptable accessibility for all people living and working in the city. The best accessibility of the most attractive public transport modes (underground, tram routes, stops with many bus lines) should be organized in areas with the most intensive land use.

4. In obligatory/purpose trips the walk should be safe, pleasant and as short as possible (time is money). The detour factor of the pedestrian's pathway leading to the public transport stops has to be low and in case of high upgrades, construction of escalators or elevators should be considered. For increasing walking distances important in pedestrian ways planning and design are also technical, functional and environmental factors.

5. The presented method is prepared for validation of walking comfort and public transport stops attractiveness and their accessibility. It is an important tool for measuring living conditions. It can be used by the district governments as well as citizens from local communities to measure and compare the level of walking comfort, transport services and living conditions in particular neighbourhood.

6. The A(PT/Ped) index of public transport stops attractiveness for pedestrians living in particular city area can be used by city planners and public transport providers for making city standards for different city zones, depending on density of population and work places. This index will be also used for property market analysis. Nowadays, when the streets are blocked by traffic jams, good accessibility of public transport modes increases real estate value by even more than 10%.

Interventions, strategies and policies that can improve the pedestrian situation.

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'Taking care of pedestrian
is managing everyday lifes' commonplace events,
is having an interest for and being sensitive to the unseen.
No glory nor glamour.
It is all about discretion, and is nevertheless our lifes' foundation.'
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Summary

Strategies and policies that can improve the pedestrians' situation cover a large range of domains and actors. European wide, at a first stage policies are more or less always focused on safety issues (pedestrian as a vulnerable user, road safety towards children and elderly people) and reactive approach (problem oriented). Since the beginning of 2000 some countries or big cities such as London began to develop more proactive and global policies, considering walking as part of durable transport and urban quality, also linked with health issues: walking as an everyday body exercise.

Urban development remains a major issue for walking possibilities and public transport efficiency. Awareness, developing knowledge, stimulating willingness among policymakers and practitioners are important points: walking is the most natural and the most used way of moving, but a way which has been and still is, paradoxically, the less known and considered: skills on the issue are widely missing. The growing interest in pedestrian issues has to be fed with researches and publications, education and training, pilot projects, sensitizing actions involving professionals, policymakers and people. Since safety issue remains an essential point, the image of walking and pedestrians has a large potential to evolve in a more positive way: walking as the core of mobility, and pedestrian as a crucial ingredient of urbanity.

The chapter is based on the analysis of relevant elements from the country reports delivered in the frame of COST 358, involving 20 countries. It identifies domains where interventions, strategies and policies are undertaken - or should be -, and when possible what sort of effects and improvements can be expected. It also tries to highlight specific situations and examples from the countries involved, in the following different domains: planning and transport, road safety and traffic calming policies, research and publications, training and education of practitioners, impulse tools and programs, incentive actions towards users, lobbying and involving of actors.

[1] Director Planning Department City of Geneva, about Plan piétons/Pedestrian Masterplan

1. Introduction

This chapter is based on the analysis of relevant elements from the country reports delivered in the frame of COST 358, taking the opportunity that most of the 20 countries involved in the project documented the situation through a country report regarding: data on walking, publications and research, policy-making, legal framework, best practices and innovations and “general atmosphere”[2]. This analysis is completed with elements coming from previous European researches and projects, such as COST C6, PROMPT, WALCYNG, PROMISING, ADONIS, and coming OECD PUSH.

The chapter aims at documenting three aspects:

- identify domains where interventions, strategies and policies are or should be undertaken;
- identify what sort of effects and improvements can be expected;
- highlight as long as possible specific situation and examples from the countries involved.

1.1. About “improving the pedestrian situation”

“Improve pedestrians’ situation” is a large issue. It concerns many domains, different scales - from local to large, concrete improvements - visible, measurable - or less perceptible, objective or subjective**.** It can act on pedestrians as persons or on some specific categories, on the image of pedestrian and walking, on awareness and action of political and professional actors, on quality of urban space in general, on social integration.

“Improve pedestrians’ situation” also covers a lot of possible improvements such as:

- **road safety**: less accidents, less fatalities or severely injured, growing part of children walking or cycling alone on the way to school,…
- **security**: parents are less fearful to let their children using the public space alone, less fear using public space at night (particularly women, old people);
- **comfort**: comfortable mobility (operational perspective), quality of the surface, snow removal, benches, light, pavement lowering to cross, large pavements,…
- **well-being**: agreeable walking, pedestrian feels as being taken seriously, biofilia, lively environments,…
- **space design**: enhancement of public space, trees, legible routes,…
- **pedestrian network**: improving connectivity (creation of short-cuts, rights-of-way, new pedestrian paths, new pavements, improvement of crossings,…)
- **intermodality**: enhancing public transport accessibility (time-table, frequencies,…), improving accessibility to stops, information, attractive tariffs,…
- **urban planning**: urban space better adapted to the pedestrian, better facilities and everyday services, town of short distances,…
- **health**: better health through physical movement (obesity, cardiovascular problems)
- **social life**: liveable public space, “social eyes”, presence of people
- **awareness, getting expertise**: authorities, professionals, economic agents, administrations, organizations, media,…
- **image**: improvement of the image of the pedestrian (social status), to value walking,…
- **communication**: “inoculation” (WALCYNG), contra-arguments,…

[2] Country reports to be downloaded on: www.walkeurope.org.

1.2. About interventions, strategies and policies

Interventions, strategies and policies can be directly focused on pedestrian, but pedestrians' situation is also – perhaps mainly – influenced by policies, interventions, actions in an *indirect* way: urban planning, transport policies in general,… and in general by social and cultural atmosphere, economic situation of a country. Interactions are multiple and it is pretty difficult to identify what exactly results from what.

Domains that can be identified through the sources mentioned are:

- **planning and transport policies and strategies**, at different scales (from national to local);
- **urban design** (pedestrian networks, streets design and refurbishment,…)
- **road safety policies**, at different scales (from national to local, road safety education for drivers, for pedestrians), traffic calming policies;
- evolving **legal and normative standards** (regarding transport, street users rights);
- **research policies and publications** (getting and communicate knowledge) - many domains are concerned: urban planning, transport, psychology, sociology, statistics, GIS, communication technology,...;
- **training** of practitioners (basic and post-graduate);
- **awareness, sensitizing actions** towards political circles and practitioners;
- **incentive actions towards users**;
- **communication**;
- **pilot programs and projects**;
- **administrative structures** (delegates specialized in the issue);
- **technical** and **technological innovations**;
- **services** facilitating walking instead of motorized travel;
- **lobbying** (pedestrian associations, specialized associations and organisms);
- **tools** and **processes**.

Beside political authorities, a wide range of actors are or should be concerned by these issues, such as practitioners, practitioners organisations, public transport companies, norms "producers", training structures/academia, health organisations, organisations/associations for the defence of persons with disabilities, inhabitants/parents associations, economic circles (firms, trades), media,… And pedestrian associations, when they exist, or transport associations, that often play an important role in lobbying and expertise.

1.3. Structure of the chapter

This chapter doesn't presume being exhaustive (some points are not detailed, as detailed information lacked), but it tries to show the complexity and to illustrate the domains concerned. It delivers *qualitative* evaluation and examples of (when possible European wide) practices – more than quantitative data: effects are often hard measurable (too complex to be), and when they are, often not measured, except in the frame of pilot projects or special actions.

The chapter is divided into three main sections. The first part deals with urban planning, land use and transportation policies, which represent a determinant frame to enable the "city for pedestrian". The second part deals with policies improving road safety: although pedestrian should less and less be reduced to a "vulnerable user", action on road safety remains a very important precondition for comfortable travelling on foot.

The theme of infrastructure and public spaces is not dealt with in the present chapter, but is discussed in a separate chapter (see section B.1.15 Design of the walking environment). The third part presents “non-infrastructural” aspects that take more and more importance regarding pedestrians: research, impulse actions and tools, education and training, lobbying.

2. Land use and transportation policies

Forty-five years after the publication of the "Buchanan’s Report" which suggested a redefinition of urban mobility and more than around thirty years after the implementation of the first "woonerven" in the Netherlands which dedicated a fundamental rebalancing of the use of the public realm, both events participating in the small Copernican revolution regarding the way of thinking on the space and the city in Western Europe, it doesn’t seem useless making a fast survey of the results gathered in favour of the “soft / slow mobility” due to different development and transport policies as well as the thorough tendencies which could orientate the development of this type of mobility in the next decade.

We here need to picture a few milestones in order to focus our comments. The end of the twentieth century has been marked by some turnovers which continue to imbue durably our ways of thinking. The awareness of the limitations of the ecosystem "earth" and the end of an optimistic idealized image of the technological development became two major concerns. Most observers definitely agree that the current system is not sustainable, and the motorized transport modes in particular, unless if undergoing deep transformations. The peak of oil production seems now very close (if not exceeded) since in the last decades, emerging countries like China, India or Brazil appeared on the market of energy consumption. Their demand is such that it risks of generating crucial supply problems for the whole planet. Besides, numerous other effects of our mobility system impede on the environment: atmospheric emissions, noise, safety, land consumption. They all are quite undesirable, especially in this context of the questioning and the increase of emerging countries standards. Finally, the disintegration of the traditional urban fabrics and the loss of social cohesion resulting from an inappropriate mobility put in danger the classic European socio political models.

The above reported evolutions already brought into light these dangers and the implementation of measures in favour of a more responsible mobility (reinvestment in the public transportation, safety and conviviality of the public realm) aimed at decreasing the medium-term impact of such dangers, otherwise avoiding them totally. Evidently, these investments have not been useless. Following the country reports, the positive effects of these measures come clearly into light in all countries:

- Spectacular improvement of the road safety despite the continuous increase in individual car use (number of vehicles and travelled kms) ;
- Improvement of the performances of vehicles (consumption, safety, comfort, …)
- A better awareness of all users sharing the public realm ;
- Improvement of the know how in the conception of multi-use and friendly public places, particularly in favour of non-motorized users, and above all for their most vulnerable ones: the youngsters, the old persons and the less valid.
- Contribution to a recent rediscovery of the virtues of the specific European urban model mostly considered as an inalienable cultural heritage. Concepts such as “*Compact city*” or “*Smart growth*”, broadly used and clearly referring to the European model, are particularly highlighted for this purpose.

The assessment of the evolutions introduced in the early seventies seems thus undoubtedly positive for categories of users who had rightly felt abandoned by the overvaluation of the motorized mobility directly after World War 2.

In a sense, one can claim that the improvements are such as any further qualitative gain seems to have to result from the implementation of more and more sophisticated techniques with a subsequent decrease of the cost-benefit ratio.

In these conditions, some radical changes of paradigm regarding the use of the city and the place of the pedestrians in it, may emerge as the necessary next qualitative steps, in accordance with the environmental sensitive context, for instance:

- **City zero emission option** as global urban model dealing with several concepts in numerous fields, for instance : the "car free city" concept in the field of mobility, the "smart growth" and the "compact city" concepts in the field of urban planning and land-use, self sufficiency and auto regeneration concepts in the field of housing. Actually such a broad model remains mostly theoretical, intending to be a laboratory of partial experiments that allows the analysis of interrelations between various fields of intervention. This model intends maybe to become the new urban utopia of the twenty-first century replacing the social and functional utopias of the nineteenth and twentieth centuries, as the environmental imperatives would take value of civic contract and as techniques and adequate social and political postures would develop in all the domains of the development of the city. Such a model strongly privileges the human powered travel's modes presenting by far the best environmental balance sheet compared to all the motorised modes.
- **Road safety zero victim option**: the "Vision Zero" option such as it is identified in Sweden and in Switzerland for example, admits:
  1. That it is undoubtedly impossible to improve road safety performances beyond a certain limit, without a paradigm shift involving interventions on the road's network, but also, upstream, interventions on the vehicles and, downstream, interventions on the users and the way they move.
  2. That the consequences of the inevitable accidents have at least to remain mild in terms of human damages.

  The "Vision Zero" concept calls on notions like "Smart Vehicle" developed by the car industry, "Shared space" developed by the planners, "Forgiving infrastructure" developed by the network managers.

  Without doubt, a greater use of walking contributes to the realization of the option "Vision Zero" by decreasing obviously the number and the severity of accidents.

2.1. What about the European governance systems in the fields of urban land use and transport policies?

The European participating countries have very diverse kinds of political organisation, either as centralised or federal states. Nevertheless, one can generally point out 3 pertinent decisional levels:

- A **global** decisional level: generally responsible for the establishment of a regulatory framework supervising the interventions of the subordinated authorities (for example definition at the highest level of general objectives for a country development). States or their auxiliaries play in this frame a role of supervisor which they exercise by means of the control of opportunity or legality. On the contrary, these authorities can also have an incentive role by organizing the sharing out of the public financial resources via transfers

- A “**glocal**” decisional level: it is about an entity (region, canton, province, land) which forms an intermediate level between the global level (state) and the local level (municipalities). In Europe this level of authority has a variable geometry according to the systems of organization of the state (federal or not): either it does have a wide autonomy associated with important means (generally in the case of a federal system ; in some cases, the higher level may radically disappear : for instance, in Belgium, the federal state transferred to regions all its skills in territorial development), or, in the other extreme, this level of power is virtually non-existent having no political, technical or financial control lever at disposal. All the scenarios are possible according to the size and the sensibilities of the concerned populations but this intermediate level is often considered as essential to ensure some coherence and efficiency to the policies led at the higher and lower levels.
- A **local** decisional level: it is generally the level of implementation of the policies defined at the superior levels and, regarding the pedestrian mobility. It is probably the most relevant level of intervention. The autonomy of the local policies is more or less strongly bound to financial resources which largely determine the human and technical capacities potentially involved; it’s also bound to the more or less strong integration of the principle of subsidiarity in the political culture. The size (or the importance) of the entities also plays a role in the capacity to develop coherent local policies.

Some more particular observations can be taken from the country reports are noted below.

2.2. Common elements picked up in the field of planning, urban land use and development policies.

In almost all the examined countries, the “rules of the game”, although relatively complex (or more subtle than what appears at first) because involving mechanisms at political, legal and technical levels, seem however relatively homogeneous and in compliance with the decisional levels sketched above : the general principles are fixed by the highest levels (State, Regions, which arrange skills of orientation via the so called "structural or strategic planning", formalized under the shape of relatively large-scale "sketches" or "plans") ; the implementation measures are within the competence of local authorities (the municipalities or a grouping of municipalities which have the power to carry out the structural plan under the more or less strict control of the first ones and via detailed equipment or development plans concerning smaller delimited areas.

In every case, at the highest levels, the national rules relative to the Town and Country planning seem to integrate some invariant ends which are:

- To manage qualitatively the living environment;
- To use the ground in a thrifty way and in a prospect of sustainable development, considering it, either as a physical support essential for the development of economic, domestic and public activities, either as a non renewable resource essential to maintain and transmit landscapes, biodiversity, natural balance;
- To preserve and value the natural and human heritage;
- To harmonize the spatial effects of a large range of policies by coordinating them, with the aim of answering the economic, social and environmental needs.

Consistent with such general principles, one can find here and there, although very rarely, some explicit references to the concern “soft mobility” as a derived consequence helping to reach sustainable spatial organization targets.

Among the rare cases treating specifically of pedestrians at this levels, one can quote for instance, the European charter for the rights of pedestrian (1988) and some punctual political guidelines for the regional / federal land-use policies.

Example of guidelines for the Walloon regional land-use policy (extract)[3]

"Share fairly the public realm for the benefit of all the users: the public realm performs at the same time a function of stay and a function of traffic. The function of stay requires quietness, safety and security for the pedestrians ….

To circulate better, circulate less: to circulate better, it is necessary to choice the most appropriate transportation mode, which is often the one who will be the most environment-friendly and improving the quality of everyday life. As regards the movement of the persons, one shall facilitate in order of priority walking and biking, then the public transport and finally the private car. This naturally has to come along with a strategy of territorial development facilitating this hierarchy.

Improving the mobility of the cyclists, the pedestrians and the impaired persons : the decrease of the speed of cars on most of the urban public roads and streets supplies an opportunity to allow the cyclists, the pedestrians and the impaired persons to move safely and conveniently. Both measures, limitation of speed and improvement in favour of the not motorised traffic, should moreover always keep pace because they strengthen each other."

On the contrary, at the local level, concerns about walking and the refurbishment of the public realm are relatively common either as norms in the urban planning rules, or in the local policies guidelines. One can quote here, for instance:

In **Switzerland**: the so called "urban area projects" introduced by the Confederation, aim at developing articulated urban development and transport concepts in a perspective of sustainable development. Moreover, the canton of Geneva requires all the municipal strategic plans to contain a specific chapter about pedestrians, but it seems to be a specificity of this canton.

In **Poland**: pedestrian networks are planned in all local land-use plans. Imperative norms for designing the sidewalks and the pedestrian ways are defined in the Act on public roads design standards. Such norms could be part also of the mobility and transport policies (see below).

Example of normative design standards for pedestrian facilities in Poland [4]

Along the urban main roads, a sidewalk has to be distant from the curb (from 3,5 m to 10 m).
Along the streets of lower classes, sidewalk can be implemented directly besides the road lanes.
In general the height of the curb is comprised between 6 to 16 cm.

Minimal width of the sidewalk: 2,0 m. This minimal width could be 1.5 m or 1 m only for a short section. It should be larger:

- by 75 cm if street lighting poles are implemented on the sidewalk ;
- by 50 cm when sidewalk is adjacent to building walls, fences or bicycle routes;
- by 60 to 120 cm if trees are implemented on the sidewalk.

[3] SDER (Schéma de développement de l'espace régional), Région wallonne 1999, Target 6 « Improve the accessibility of the Walloon territory and manage the mobility », pp. 199-208.
[4] « Rozporzadzenie Ministra Trasportu i Gospodarki Morskiej w sprawie warunków technicznych jakim powinny odpowiadać drogi publiczne i ich usytuowanie » (Act on public roads design standards) published in 1999.

The sidewalk gradients cannot be higher than 6%. When the slope is steeper, ramps or stairs should be applied. One stair section can have 3 to 13 steps, and up to 17 steps in case of a single stair section.
The minimal stair width is 1.2 m. The maximal height of a stair step is h = 17.5 cm and the step width w = 30 to 35 cm, but 2h + w should be limited to 60 / 65 cm.

The maximal gradient of a ramp is 8%. 10% are acceptable only when the ramp is under a roof or its length is less than 10 m. In case of longer slopes a ramp should be divided into sections. The maximal length of one ramp section is 8.0 m and the minimal distance between two ramp sections is 1.5 m of flat area. The minimal ramp width is 2.0 meters.

Depending on the type of sidewalk pavement the transverse slope can be 1 to 3%.

In **Belgium** (Walloon Region): each local strategic development plan has explicitly to contain proposals concerning the mobility of the pedestrians (see here above the Swiss canton of Geneva). The regional regulation on some protected urban cores (it deals with most of the city centres previous to the 18th century which present a cultural or aesthetic interest), contains minimal requirements for the sizing of the pedestrian itineraries, and those are uniformly applicable to the totality of the regulated perimeter. Also, regional regulation fixes minimal standards of access to the public equipments (in the broad sense: building or any other public place) for the less valid persons; respect of these regulations is a condition in order to obtain the legal building permit.

2.3. Common elements picked up in the field of mobility and transport policies

In the great majority of European countries, the main part of the transport and mobility policies stays, for very understandable reasons of coherence and standardization, in the hands of public authorities at the highest level. Still it is advisable here also to distinguish the purely statutory and organizational aspects defined in a code, without any spatial references (for example the traffic rules), from some project initiatives which are translated in local mobility plans, which are bound to a concrete space of analysis and implementation and which are within the competence of the “local” authorities managing the studied area.

At the general level, the European traffic codes present a remarkable standardization, essentially dealing with traffic and paying no particular attention to the most vulnerable users. All over Europe, the measures relative to the pedestrians carry systematically on :

- The obligation to walk on the pavement when it exists, or, in opposite case, the terms of restrictive use of the passable area ;
- The "design" of the pedestrian itineraries additionally to the urbanistic rules evoked above (free width and height at a minimal level, possibly the typology of the furniture and\or the road marking) ;
- The management of the crossings on public road network (with or without zebra, Pelican, Toucan, Puffin markings).

One can quote here two original national approaches:

- **Belgium** where the previous “*Traffic code*” turned into “*Street code*” with a main rule : the drivers have, in any circumstance, to pay attention to the most vulnerable users [5]

[5] Modification of the original traffic code (1975) into “Street Code. Law approved on 4.4.2003, coming into force : 1.1.2004

General regulation on the road traffic police and on the use of the public realm in Belgium

TITLE II - RULES FOR USE OF THE PUBLIC REALM
Article 7. - Main rules of behaviour for the users of the public realm.
7.1. Every user has to respect the measures of the present Code.
…. the driver cannot put in danger the most vulnerable users, in particular the cyclists and the pedestrians, notably the children, the old persons and the disabled persons.
As a result, …., every driver of vehicle has to double caution, in the presence of such vulnerable users, or on the public realm where their presence is predictable, in particular on the public realm such as defined [in the Code].

- **Switzerland** : we have to underline that Switzerland seems to have a cutting edge position in favour of human powered mobility. It is maybe the sole country whose Constitution contains something about the pedestrians, exactly about the *pedestrian itineraries*. Moreover, Switzerland also has a specific law about "*the pedestrian roads and the hiking trails*" (1985), on which the Swiss Confederation lean to justify the existence of a specific unit "soft mobility" acting within the framework of the Federal Road Office. Finally, in 2002 the Confederation realised a master plan dedicated to "Human powered mobility" [6] which is a catalogue of intents and measures in favour of this kind of mobility.

Example : Pedestrians paths and roads in the Swiss Constitution and Swiss master plan dedicated to human powered mobility

Art. 88 of the Swiss Constitution : About pedestrians paths and roads :

1 The Confederation fixes the principles applicable to the pedestrians paths and roads networks.

2 The Confederation can support and coordinate the cantonal measures aiming at development and maintenance of these networks.

3 The abandoned or deleted elements of the pedestrians paths and roads network are renewed or replaced.

The Swiss master plan is organised around 13 guiding principles and corresponding measures allowing to reach the fixed objectives.

This plan is binding for the public authorities which introduce it. It has value of recommendation for the other actors of the mobility.

As regards the planning of the mobility at the local level, the mobility or transport plans are, all over Europe, at least realized in a perspective of rebalancing the modal shift in favour of the least damaging modes, in the respect for the principles of the sustainable development. Such plans generally include a section handling with "human powered mobility". This way, we can claim that walking, following the example of cycling or public transport, acquired an uncontested position more than purely symbolic in the contemporary way of thinking and solving the mobility problems.

This type of planning doesn't moreover content anymore with approaching coarsely the question of the management of vehicles flows. Peripheral or cross-cut points of view are here quasi-systematically adopted in order to enrich or prove the recommended solutions:

[6] http://www.astra.admin.ch/themen/langsamverkehr

- environmental constraints (diverse pollutions, global warming) ;
- road safety ;
- public health ;
- urban renewal ;
- education and didactics.

These different points of view converge all in the direction of a greater potential of development for the travelling modes having "naturally" the *best social acceptance* and the *best cost / benefit ratio*. Walking is generally presented as such.

Nevertheless, it is often far from the planning to the realization and still in numerous cases, this way of thinking seems not to become a reality with the rate or the scale we would wait for.

It is true that the local mobility plans sometimes result in a plethora of measures among which choices must be operated according to the urgency or the budgetary constraints. We could be afraid that the measures specifically in favour of the pedestrians will be considered neither as urgent technically, nor as a budgetary priority. Here is a true subject of concern according to the country reports. It is particularly true regarding the caricatured differences of investment between what is assigned to the motorized mobility and what is left with the alternate travelling modes.

In addition, the mobility plans can be supported by "pedestrian charters" (among others: Montreal, Lyon, Lille, Douai, Toulouse, following the example of the European charter for the rights of pedestrian) or “strategies for sustainability” (among others : Zürich, Berlin) which can possibly orientate or mark out the propositions of interventions defined in the mobility plans. As said before, it is however necessary to notice that these documents, however well-intentioned, too often stay at the stage of a catalogue of examples, without contractual constraint towards authorities.

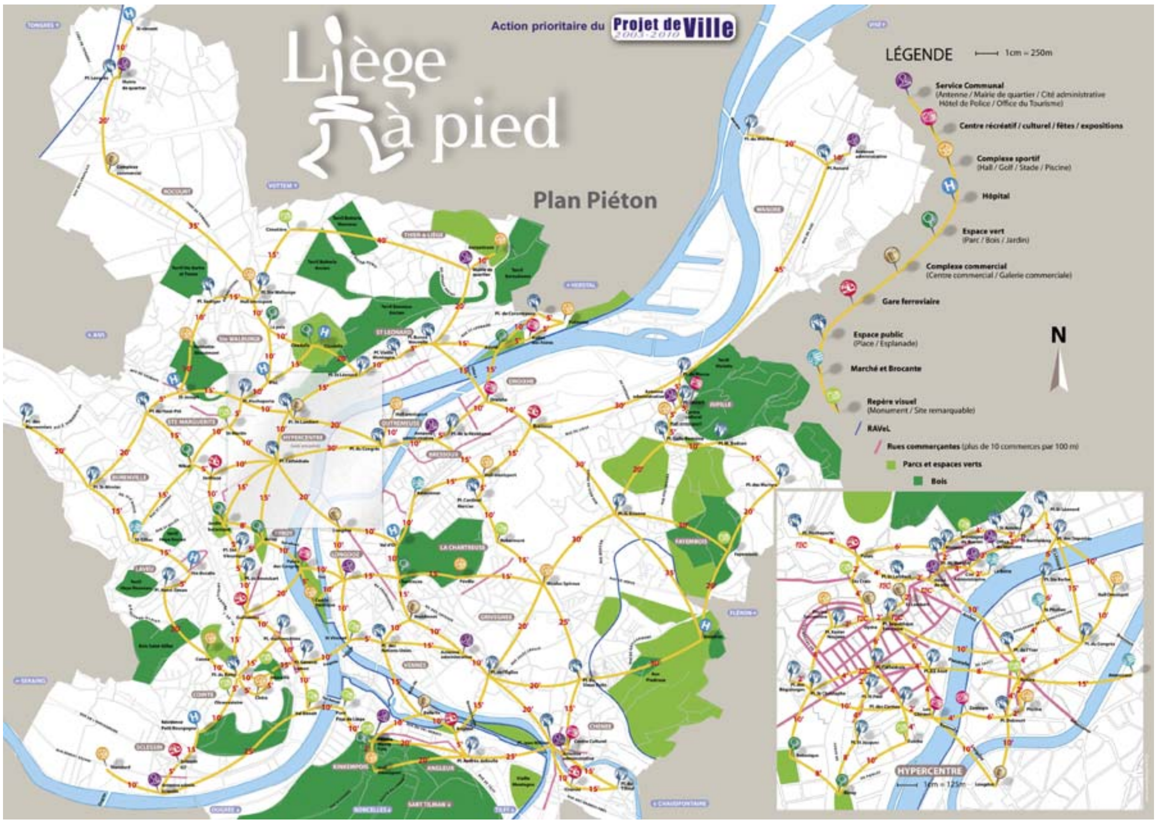
To mitigate this problem, certain cities (in still reduced number: Geneva, Liège, Strasbourg-Illkirch) introduced the realization of "pedestrian specific plans", including some budget and some realizations dedicated without ambiguity to walking. The Geneva case is in this respect an instructive reference of the fact that a procedure of recognition by public inquiry can lead to a shape of contractualization and obligation of result.

The marking out as a vector of the legibility of the itineraries, the treatment of the punctual problems (crossings, missing links), the traffic calming measures, the development of the local heritage and the security measures regarding the public realm are the basic elements on which these specific plans generally lean.

In the same field, one find very usually thematic mobility plans : safe routes to school program, accessibility plans for the least valid, planning of itineraries for leisure activities, which are intended to answer at the expectations of more or less captive pedestrians (pupils, handicapped persons), even militant (walkers, joggers).

At least, some public authorities may appoint a person in charge of the specific problems connected to the pedestrians and to the implementation of plans and strategies in this field (Liège/B, Bienne/CH).

Specific planning tool : the city of Liège has elaborated in 2004 a "Pedestrian Master Plan" which is a priority action in the city project 2003 – 2010. [7].



The plan draws up at first an inventory of Strengths, Weaknesses, Opportunities and Threats (SWOT analysis) relative to the pedestrians mobility in the city.
The 4 phases of the reconstruction of the city centre around the pedestrian are reminded :

- The "pedestrianization" of the city centre around galleries, passages and commercial poles. This realization began in 1965 and continued to 1990s.
- The realization of "semi-pedestrian" streets between 1990 and today. It is about traffic calmed streets, with speeds limited at 30Km / hour and accessible only to the local traffic.
- The development of quiet spaces for the relaxation (places, public gardens) implemented along the pedestrian streets network within the city centre. These spaces also provide accessibility to the public transport system and comfort to the public transport users.
- A last current phase which consists of the requalification in favour of the pedestrians of the car oriented road network penetrating to the city centre

The vision for future developed in the Pedestrian Plan aims at valuing some strategic places where the pedestrian is omnipresent, namely :

- the interfaces with the public transport system (train / bus) ;
- the crossing of highways, rivers, railroads or large streets with an important traffic ;
- streets and crossroads in commercial sectors or within the centre of housing districts ;
- the improvement of de facto pedestrian parts of the network : staircases, dead ends, alleys or paths ;
- the neighbourhoods of pedestrians generative poles : schools, hospitals or old people's homes ;
- the places for walk and leisure in the city : river banks, parks or public gardens ;
- public realm with an important pedestrian passage and which can be used for festive events or to emphasize buildings with high architectural or historic value ;
- the new extensions of the housing where the priority must be granted to the pedestrian connections.

[7] Le Plan Piéton de la Ville de Liège, 2004 (http://www.liege.be/planpieton/plan.htm)

The Pedestrian Plan comprises some recommendations and a priority plan devoted to the practice of walking. It is organized according to two main axes:

- the main itineraries, so called "Big Roads"; they privilege at the same time the access to the city centre and the main connections between the urban districts ;
- the neighbourhoods centres, namely these sometimes reduced spaces but which are above all places of meeting and relaxation. These places, which can be a square or simply a small enlargement of the public realm, are indispensable to the appropriation of the district by the inhabitants and serve its social cohesion.

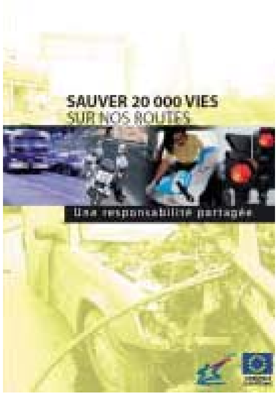
The Pedestrian Master Plan of Liège has the status of a not imperative recommendation. It is supposed to be a statement of the existing pedestrian developments and to propose guidelines for future developments of the public realm. No obligations for results, nor external evaluation are requested. There is no specific budget allocated to the realisation of this plan (the improvements to the pedestrian network are included in the general budget devoted to the municipal public works department). On the other hand a person in charge of the human powered mobility was appointed by the city of Liège to implement the measures in favour of the pedestrians lauded by the various plans of development of the city.

3. Safety policies and strategies

Road safety remains a crucial topic European wide. Although much progress can be observed since three decades, the situation is unacceptable: 43'000 persons killed and two millions wounded on the road in 2004, in the 15 countries of the European Union. Road safety appears as a major society and public health problem.

New approaches in road safety policies at national level have been implemented in Sweden (Vision Zero) and in the Netherlands (Sustainable Safety), both having inspired the road safety policy in Switzerland (Via Sicura). Their objective is a reduction of 50% in the number of deaths due to road accidents, through a catalogue of actions and a preventive approach. They are based on the principle of "shared responsibility": users are responsible for their behaviour, while authorities must conceive infrastructures that bear the occasional user mistake ("Forgiving Roads"). In the Netherlands, a reduction of 12% of the number of victims has been observed from 1997 to 2003, and 8% of severe wounded people.

In 2001, the European Transport White Paper decided as an objective to reduce 50% the number of victims until 2010. This objective was reiterated in 2003 through the Road Safety Action Program, which lists 60 concrete actions. The European Commission attaches great importance to vulnerable users in cities, according to the fact that two thirds of body accidents happen in agglomerations, and totalize one third of killed people. Pedestrians and cyclists are the most vulnerable. Many initiatives are linked to this objective.

	Road Safety Action Program of the European Commission (2003). The document can be downloaded on www.ec.europa.eu

3.1. Traffic calming policies, from separation to cohabitation solutions

At local level, policies evolve from a strict separation of road users to cohabitation, through refitting streets and redistribution of space between users. Traffic calming and lower speed limits are the indispensable instruments of this evolution.

30kph zones exist in more European countries since 1980'. Some countries have developed global policies. In Germany there are hundreds of zones, in Switzerland the "50/30 model" – systematic 30kph zones out of main streets network – has been realized in most big cities, and begins also to appear in smaller communities. In Austria, it is possible, according to the law, to put a whole city at 30, like in Graz, though it remains an isolated case for the moment. In France 30kph zones are used especially in city centres, or near schools. Lower speed is no longer limited to district streets with low traffic, as showed through recent refurbishment of main road in Nantes/F (Cours des 50 otages) and Köniz/CH (Schwarzenburgstrasse), which are signalized at 30kph.

In Sweden, a new speed limit system has been introduced. For cities the main difference compared with the old is that 40 and 60 kph were introduced as new speed limits. One of the result is that streets with former 50 kph-speed limit is changed to 40kph, to the benefit of pedestrians. The Netherlands introduced 60kph zones in rural contexts.

Integrated road safety: a pilot project in Gloucester

The project was developed by the UK government. The pilot project ambitioned to demonstrate that the number of accidents in a town should be noticeably reduced through the implementation of an integrated safety program. A budget of 5 millions £ was dedicated to the project for a period of five years (1996-2001).

The method was defined in a document of recommendations on road safety in cities published by the IHT. It began with a global diagnosis of dysfunction at town scale. Then measures were implemented, such as:

- definition of the hierarchy of roads;
- reorganization of traffic, in order to distribute it on certain roads, others being closed, or refitted, creation of bus lanes;
- traffic calming through sensitizing actions (articles in the media, information on fines, radar with dynamic display), streets fitting out (traffic calming elements) and controls by the police;
- actions aiming to facilitate walking and cycling: large traffic calming zones, elements helping in crossing the road, cycle lanes, signs on the way to school,…)
- coordination at administration scale of all actions influencing road safety.

Key point was the management structure of the project, which was opened to many stakeholders and carried out large information and dialogue.

Finally the project was a real success: reduction of 9.5% of accidents, whereas increasing of 8.5% in case-control towns, and important decreasing of severe accidents (48%). People drive more slowly.. Public opinion was very favourable. More people, especially children, move on foot and cycle ion the way to school. Based on the positive experience, the English government decided to develop other pilot experiences.

In Belgium, Code de la Rue /Street Code approach and street for all

Introduced in 2004, the Code de la Rue includes a range of elements aiming to allow a better share of space and more safety for pedestrians and cyclists. The objective was to introduce in the law the idea that the road/street is not only dedicated to traffic, but is a space for all users, especially vulnerable users:

The Code de la Rue is a process more than a catalogue of actions. These can vary depending on the situation and legal frame of the country (the Code de la Rue approach developed in France since 2007 is not exactly the same).

In Belgium, it included:

- (re)definition of road users and spaces they can access, what highlights the necessary conviviality of public space;
- addition of the “precaution principle” and responsibility from the strongest towards the weakest;
- new possibilities offered to the communities,: introduction of the “encounter zone” in the law, cyclists systematically allowed to drive in two directions in one-way streets, 30kph near schools.

3.2. From pedestrian precinct to encounter zones and shared spaces

Car free zones in city centers conceived in the sixties evolve nowadays in new ways to deal with pedestrianization: “aires piétonnes” in Chambéry (1985), more recently “zone de rencontre”/encounter zone in Switzerland (2002), introduced in Belgium (2004) and in France (2008) linked to the Code de la Rue/Street Code approach. In the Netherlands, Hans Monderman invented the concept of “shared space” as a new way to manage relations between road users, with less signalization. Unlike shared space, where neutral arrangement is supposed to act as traffic calming element without prescription on speed limit and priorities between users, in encounter zone speed limit is low (20kph) and pedestrians have priority.

The “encounter zone” was born in Burgdorf/CH, with a pilot project experimenting home zone rules in a central district. Unlike shared space, in encounter zone speed limit is low (20kph) and pedestrians have priority.

3.3. Road safety education

Traffic education is mostly concentrated on traffic safety and on children, through policemen coming at school to educate children how to behave in road traffic. Although this education is quite necessary, several researches showed that childrens’ competences in traffic remain limited till the age of 10. Road crossing is a particularly risky affair for children, but also for elder people on foot: they both pay a hard tribute in accidents. Lower speed limit and awareness campaigns focused on drivers appear as crucial elements for road safety of vulnerable users.

Education and Training - Children

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The ability of children to cross a quiet street, cross a street with parked cars, and cross the street at an intersection was improved after training (Rothengatter, 1984). Similar results were obtained by Van Schagen (1988) in a study to train children to assess time intervals in traffic. But research has shown that training children is not clearly linked to their true behaviour in real traffic, nor what behaviour can be considered to be safe, and what can be regarded as undesirable, in traffic (Vinjé, 1981). Training children to be in traffic can give them better knowledge about how to cross a street safely, for example, but does not mean that their behaviour will be improved in acting more safely. On the other hand, it cannot be established, either, that training leads to a blind faith in the person's ability and thus to new dangers. Children are not biologically capable of moving about safely in many traffic environments because they cannot cope with all the requirements.

An alternative possibility may be that it is important to train children in safe road behaviour, but that what are learned is not the skills but the knowledge of how things happen and attitudes to safe road-user behaviour (Ampofo-Boatang *et al*, 1993). It is suggested that what children need is practical knowledge of the matter instead of descriptive knowledge. Children are not assumed to be able to link verbal descriptions to safe road-user behaviour and to implement them as road users. It is therefore proposed that training should be practical rather than descriptive.

Gummesson (2007) refers to the Cochrane Collaboration which made a study of the injury-reducing effects of training children. After a review of almost 14,000 studies of traffic training, no evidence of injury-reducing effects was found. Countries with national initiatives in education and training are no different to others in terms of accidents per capita. Recently, Sweden has moved from training and adapting children to traffic to adapting traffic systems to children. The important conclusion of how we should relate to training children to stay safe in the traffic environment is that it is not clear that it is children who should be trained to become safe road users. With the right arrangements, education of children can be seen as a component in preparing children for traffic, but that does not mean that we can trust the results of the training. It is therefore car drivers who bear the responsibility for child safety in traffic, along with the parents of the children (Arnold et al 1990). It is motorists' inadequate knowledge and anticipation of how children can react that constitutes the threat to child safety, so it is drivers who should apply strategies for driving safely on roads where there are children. The traffic environment should be designed and regulated so that motorists can take on this great responsibility. In the following chapters, advice is given as to what is required for this.

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4. Acquiring knowledge

This sub-chapter deals with issues regarding what Rob Methorst calls fundamental « preconditions »: raising awareness, willingness to act, getting competences and skills and implementation[8].

4.1. Research and publications

Change always rises from knowledge. Research is an essential point towards getting a better knowledge on multiple issues regarding pedestrians and walking. It gives visibility to the topic of walking and pedestrian and encourages its image to evolve – or not. Research activity also constitutes a way of education (getting knowledge) for the persons involved, especially young researchers and students. It can induce a “virtual circle”: more research can raise interest, then initiate more research.

Comparing to research on other transport modes, research on pedestrians and walking – as a specific theme – remains modest, but present. In most countries, an important part of publications is concentrated on safety issues (accident, risk, conflicts with traffic) – pedestrian as vulnerable users – children, older people (growing ageing population). Safe road crossing represents an important issue.

Current researches mentioned in the country reports are lead by associations (pedestrian or transport associations), “specialized” private offices, transport ministry, academic institutes (departments of transport, urban planning or design, architecture) and some students (PhD or master work), official competence centres. And, more recently: health organizations, public transport enterprise (RATP in Paris) and… car industry (City on the move).

Current researches directly linked to pedestrians :

- Road safety remains (indeed!) an important topic.
- How to promote walking.
- Relationship between walking and health.
- Walkability assessment (comparison of different cities).
- First research on non-urban areas (walking in town and rural areas).
- Mobility and ageing society (quality of life in relation to mobility conditions).
- Flow modelling.
- Young people and mobility behaviours (in different contexts).
- Mobility management.
- Psychological and sociological approaches of pedestrians and walking.
- Innovative tools for road design and collective space organization.

Early qualitative oriented and proactive researches (themes, approach, vision) are seemingly coming from pedestrian associations, from sustainable transport organizations – since ‘80-’90 –, and from a few specialised researchers and academia (thesis). Researches issued by official circles (national institutes) are often more technical and safety oriented, but this also is changing.

[8] METHORST Rob, “Picturing a desirable system”, OECD PUSH report, draft chapter 3, *to be edited 2010 (working group on pedestrian safety, urban space and health, 2008-2010)*

There are still few researches focusing on walking as a potential and considering pedestrians in a "positive" way, this is to say: not only as a vulnerable user. But since the beginning of 2000, one can observe European wide a growing interest and growing body of research and researchers who are looking at issues related to walking and other active modes of travel, outside specialized and initiated circles (associations). While safety related issues still remain important there is also a lot of interest in walking as a sustainable mode of transport and in the way of encouraging behavioural change (UK, CH). In some countries, people interested in friendly mobility focused on cycling, but new interest in walking is raising, more evidently since two or three years (F).

Some recent research programs on transport did include researches on pedestrian issues (F, CH, UK), but there has been so far no specific research program focused on pedestrian and walking issues. Beside research programs, some countries offer research program lines where it is possible to get some money for pedestrian research (A, CH).

However, many delegates stress that the budget spent for pedestrian related research is still quite low comparing to the budget for car related issues.

What about dissemination? For how long have results and reports are been known? In what circles? This is rather difficult to evaluate from country reports. Websites can play an important role as information source and access to reports (often downloaded). Integrated practitioners post-school education help to promote constant improvement of the education (and thus of the field), symposia, conferences and hand/guide books, websites, Wikipedia,…

There is also growing exchanges between researchers on pedestrian issues, at national or international level, since the end of 90s', through European programs or international events. At international level, Walk21 is the most important event entirely dedicated to this issue. It is organized every year since 2000 (www.walk21.com).

Research programs

Research programs in countries comprehending researches on pedestrians and walking: PREDIT (F), PNR 41 (CH), EPSRC research programme on walking and cycling, jointly with SUSTRANS (UK).

In Austria, the research program line "ways2go" of the Austrian Ministry of traffic innovation and technology supports development of innovative transport technologies. In the last call, 36 projects were financed, 2 dealt explicitly with pedestrians and 21 projects implicitly (e.g. projects that might have some positive effects for pedestrians).

In Poland: programme GAMBIT 2005, focused on road safety.

In Switzerland: some researches on pedestrian issues with financial support from Road Federal Office – domain slow mobility.

In Sweden: HASTA, program for developing an attractive and sustainable urban traffic, with a sub-project dealing with "How to increase walking and cycling and also make it safe".

European research programs, actions: PROMPT - New Means to Promote Pedestrian Traffic in Cities (2003), COST C6 (2001), PROMISING - Promotion of Mobility and Safety of Vulnerable Road Users (2001), WALCYNG - How to enhance walking and cycling instead of shorter car trips and to make these modes safer (1998), ADONIS (1998). DUMAS - Developing Urban Management Safety (1997-2000).

Recent conferences and events:

A / Organized by walk-space (www.walk-space.at).

CH / Every year, organized by the Swiss association for pedestrians every year, on behalf of Road Federal Office - domain Slow mobility (www.fussverkehr.ch).

F / PFI-COPIE in Lyon, conferences CRESSON in Grenoble, the RATP (public transport enterprise in Paris and region) launched a rate of meetings about walking in 2009, Conference "La ville en marche" (Mairie/Government of Paris) 2010, events organized on walking by the Club des villes et territoires cyclables since two or three years.

UK / Institute of British Geographers conferences.

4.2. Education and training

Walking is the most natural way to move. Dealing with pedestrian issues requires yet to get specific knowledge and competences. Training future practitioners is an important question, but this merging subject is still at an early stage compared to more technical questions in traffic issues.

Training is the way to develop a body of knowledge and specific abilities. It gives the opportunity to raise interest for the theme, develop research and thesis. It contributes changing the perception and image of walking and pedestrians, making the theme visible as well as recognizing it as an important stake, and sometimes leading to the creation of private business offices with specific knowledge and interest in the issue. It has no short-time effects, but long-time change that has to be prepared today.

Education and training concern different domains and specialists: architects, engineers and geographers, but also sociologists, psychologists, educators, legislators, designers, IT specialists, managers and so on.

Country reports do not contain much information on this question. Lists of publications suggest some universities and researchers-teachers specialized in the domain. Where there are teachers, there are also student works and thesis focused on the issue.

In most countries, basic training is ensured at university level and by specialized high schools, usually at Civil Engineering and Architecture Faculties. Pedestrian issues are not commonly included: engineering programs are focused on the management of motorized traffic and rather technical questions, architecture programs analyse public spaces but not on network-based solutions. Geography is more oriented towards social sciences, and may include specific teaching.

Teaching on walking and pedestrian remains modest, most professionals do develop interest and competences later on, on an individual basis, and knowledge is acquired on the field. However, things are starting to change: at university courses on transport, usually at Masters level (UK, S, CH), there are now some modules which consider walking with a broad approach. Several COST 358 delegates mention that mobility issues, mobility and durability, slow mobility / human powered mobility raise more and more interest among students. "The pedestrian is on the periphery of attention, but no longer outside the sphere of interest" (Rob Methorst).

At present time, most interesting opportunities of training are offered by growing possibilities of post-graduate and professional training on specific topics including, directly or indirectly, pedestrians related issues: seminars and colloquiums organized in universities, mostly by associations and post-graduate organisms.

Elements mentioned by delegates

B / Education for "mobility consultants" organized by the CEM, supported by the Walloon Region (mobilite.wallonie.be/opencms/opencms/fr/formation_information_sensibilisation/cem). Education organized by the CAWAB, linked to the GAMAH (association for the protection of disabled people) www.cawab.be.

CH / WWF Training Centre in Bern, Training Centre for Sustainable Development (SANU) in Bienne www.sanu.ch. Certificate of Advanced Studies "Street urban space" organized by the Zurich University of Applied Science, School of Architecture, Design and Civil Engineering. Ongoing study on state-of-the-art of education and training (www.econcept.ch) in pedestrian and cyclist issues, on behalf of the Swiss Road Office.

E / Some post-graduate studies on road safety matters in the Spanish universities (e.g. masters on mobility or road safety engineering).

F / Teaching offer seems to be a bit different now in the programs of some schools of engineers after a survey which brought to some teachers awareness of the problem.

NL / University of Breda, special Lector on vulnerable road users, paid by CROW (Transport Research Knowledge Centre), that aims to substantiate, promote and coordinate knowledge management regarding pedestrians' needs, behaviour and facilities.

PL / Some lectures covering also pedestrian traffic are given during postgraduate studies on traffic engineering, spatial planning and urban planning.

5. Stimulating planning and action

We deal here with all interventions and actions that can improve awareness of authorities and professionals at local level, communicate knowledge, stimulate them in implementing planning and actions on behalf of pedestrians and walking.

5.1. Guidelines, publications and websites on best practices

These are very important for recognizing the issues' reality and weight for authorities and practitioners. Pedestrian and walking issues seem to remain very abstract for many persons who deal or should deal with it. Guidelines and information through examples are very useful for raising interest, giving ideas, showing what is made, in which conditions, at what cost and difficulties, in which process, what actors involved and so on.

Until about two or three decades ago, such publications came mainly from associations, showing problems and needs, illustrating evolution in public space refurbishment in favour of pedestrians and cyclists, quality of public space, urban life, many dealing with traffic calming. When coming from official circles they seemed and still seem today to be more road safety oriented.

Specific guidelines and Vade-mecums exist or are being prepared in some countries (CH, CZ, B, NL, F), sometimes being rather technical. Disabled people and design for all are important topics. There are still very few guidelines dealing with the pedestrian issues with a broad and proactive approach, linked with strategies aiming to promote walking. For more information and lists of publications, country reports can be downloaded on www.walkeurope.org.

Websites or web pages (associations, official circles, some cities)

B / Belgian Institute for Road Safety IBSR www.ibsr.be, www.bivv.be, Official webpages of the regional government services (Wallonia, Flanders and Brussels) : http://mobilite.wallonie.be, http://www.mobielvlaanderen.be, http://www.bruxellesmobilite.irisnet.be .

CH / Swiss pedestrian association: www.fussverkehr.ch, Rue de l'Avenir: www.rue-avenir.ch, MobilService: www.mobilservice.ch, Transport and Environment Association ATE: www.ate.ch, website on encounter zones: www.zonederencontre.ch, webpages of the Federal Road Office dedicated to slow mobility: www.mobilite-douce.ch . Cités de l'énergie www.citesdelenergie.ch

E / Pedestrian Association Catalunya Camina: http://www.catalunyacamina.org, Forum for a sustainable mobility in the community of Madrid.

F / Rue de l'Avenir: www.ruedelavenir.com, VeloBuc: http://velobuc.free.fr, Certu: www.certu.fr

NL / CROW (Transport Research Knowledge Center) www.crow.nl, Shared Space Institute www.sharedspace.eu

UK / Sustrans www.sustrans.org.uk, Living Streets www.livingstreets.org.uk, Transport for London www.tfl.gov.uk.

5.2. Special events

Special invents and programs make the issue more visible, and valorize what has been done. Being relayed by the media, they reach a large audience and can give ideas to other communities and professionals. It runs from local (community level) to national events (exhibition, competition).

Special events mentioned

A / Walk-Space Award, best practices in favour of walking and pedestrians.

B / Day of Public Space, initiated by Steunpunt Straten (www.steunpuntstraten.be).

CH / Contest “Flâneur d'Or” (6th edition 2008), rewards interesting realisations in favour of pedestrians, refitting street, elements of networks. First price and awards (www.flaneurdor.ch). Salon de la mobilité (Mobility fair), a demonstration organized every two year, events and contests (www.citedelenergie.ch).

F / Exhibition “The Street belongs to all of us”, organized by the Institut pour la ville en mouvement (Paris). Workshop about walking linked to the new mobility plan for Ile de France, which is studied at the moment.

NL / National Childrens' Play Day: once per year a large number of cities close some streets for traffic, so that children can play freely there.

PL / Conference Miasto Dostepne (An Accessible City) organized in Warsaw by Stowarzyszenie Przyjaciól Integracji (Friends of Integrity Association), combined with a competition Polska bez barier (Poland without barriers): the best examples of urban space designs in Poland are awarded. Bramy Kraju Program (5th edition in 2009): best solutions for urban space accessibility by disabled people.

5.3. Impulse programs and pilot projects

More ambitious (but still rare), incentive programs, with financial support, are an important way to encourage communities to develop measures in favour of pedestrians and sometimes try new solutions and process. As they need a political decision, it is also a way to give the theme some (a better) visibility and a chance to be discussed. Evaluation of the effects is generally part of the project and can bring new knowledge to the field. Communication on the project creates interest among other communities, practitioners, researchers, and can induce support for developing new solutions at a large scale.

Impulse programs

CH / 1996-2006: Pilote project in Burgdorf (Berne) "Model City for Walking and Cycling", financed through the national program Energy2000. In a sort of laboratory of ideas, many projects were developed. The most known is the "Flanierzone" (20km/h, pedestrian priority in a central district), that aroused a large interest in Switzerland, allowed changing the law and introduce the "zone de rencontre" (encounter zone). www.burgdorf.ch > Umwelt > FUVEMO.

CZ / Czech Environmental Foundation Nadace Partnerstvi support activities and campains connected with any kind of environmental transportation (included walking) www.nadacepartnerstvi.cz

F / 80s' program "Villes plus sûres, quartiers sans accidents" (Safer cities, accident-free districts) initiated innovative experiences in communities at national scale.

FI / Program JALOIN (2001-2001): task was to make the various decision-makers more aware of the importance of pedestrian and bicycle traffic and to influence the future course of development.

5.4. Evaluation tools, pedestrian and safety audits

Evaluation tools like audits can enable a comprehensive evaluation of problems. They contribute to a better sensitivity towards the stakeholders involved, by showing the range of elements that have to be taken into account. Pedestrian audits developed in England and Scandinavia are not only a check-list, bus also a process involving different actors.

Such tools exist in many countries, they are more or less safety oriented, and partly focused on children safety.

Pedestrian audits, safety audits

A / Pedestrian audits for all communities offered by walk-space (www.walk-space.at). Apple and Lemon.

B / Octopus Campain, a website allowing seeing what is done and what the results are (www.iwalktoschool.org).

CH / Pedestrian audits (by the Swiss pedestrian association), children safety diagnosis, elderly safety diagnosis (Transport and Environment Association). "Petit plan piétons"/Little Pedestrian Plan in Geneva (CH): children point problems they meet on the way to school.

CZ / Road safety audits are one of the main issues solved by Centrum Dopravního Výzkumu (Transport Research Center) in Czech Republic.

F / Method used in Paris in some districts to enhance the quality of public space. It was supported by the local group of FNAUT (National Federation of Transport Users) to design home zones and improve street design of some cross roads.

NL / KISS (Childstreet test), MMM-scan (Man-Mobility-Environment scan).

PL / Road safety audits in the early stage of implementation. Up to now only the national road administration makes internal RSA for the new sections of the national roads network. The procedure also includes pedestrian issues.

S / Audits of pedestrian planning in cities carried out by the Pedestrian Association.

UK / TRL PERS system (Pedestrian Environment Review System), assess and improve walking provision (see Transport Research Laboratory website: www.trl.co.uk)

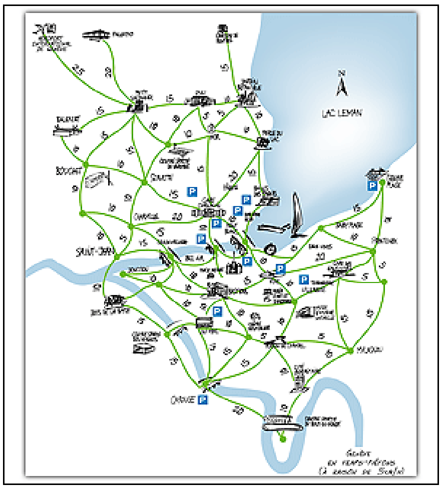
6. Encouraging and facilitating walking

The rediscovering of walking potential of the last decade has been accompanied by the development of incentive campaigns and actions aiming at promoting walking. Objectives are linked to environment and durability – slow mobility as an element of a more durable mobility –, and urban quality – pedestrian as vector of urbanity and social life in public spaces. More recently health issue motivated health organizations and authorities to promote walking as a mean to prevent obesity, blood and cardiovascular problems.

We deal here with rediscovering walking as an everyday opportunity in an everyday life context. Even if walking is a quite natural way to move, one has in a certain way to re-discover knowledge and competences, and get a new mental map of space: going from A to B is not so far et not as long as you believe. Campaigns and actions can contribute to create another mobility culture, and induce a certain modal report: in Switzerland for example, one from eight motorized trips is shorter than 1 kilometre.

6.1. Incentive campaigns and actions at local level

The actual challenge is to modify the image of walking as a sport or leisure activity, and the perception of the pedestrian as a vulnerable user. If a large part of incentive campaigns are still focused on children (on the way to school, walking buses), one can also observe more general campaigns. There is a growing interest in the field, especially in cities, but also in other “less evident” contexts – such as suburbs and villages –, to develop strategies encouraging people in moving on foot, often with a ludic dimension, for example through (thematic) walks, sometimes linked with car-free days or mobility weeks.



On foot: so far, so near!... Another mental map of the city, developed in the frame of the Pedestrian Plan Geneva (CH). How to rediscover pedestrian knowledge and competence.

Linked to the Pedestrian Plan: let's make a walk!

6.2. Company travel plans, school travel plans

Some countries mention lots of company travel plans, and emerging school travel plans, in which walking can play an important role, especially for schools. Administrations develop more and more often travel plans, in order to set a good example at public hand. Effects are most of time evaluated, they are sometimes spectacular, mostly those concerning cycling and public transport.

Campaigns, actions, travel plans

B / Company travel plans initiated by the Walloon Region (see: http://mobilite.wallonie.be).

CH / Pedibus (walking buses): 250 "lines" in the French part of Switzerland, large interest in German part too. Walks linked to the Plan piéton / Pedestrian Plan in Geneva (http://www.ville-geneve.ch/themes/mobilite/pieton/). Actions of the Ligue de la santé/Health Leagues in the canton de Vaud (www.ca-marche.ch), for example "Métro-maison" linked to the inauguration of the new subway line in Lausanne *(see below)*.
Strategy Mobilitätskultur/Mobility Culture, actions "Mobilitätsspiele" and "Züri s'Fuss" in Zurich (http://www.stadt-zuerich.ch/ted/de/index/mobil_in_zuerich/mobilitaetistkultur.html.

CZ / Action Safe routes to the school promoted by non-profit association The Prague mother (www.prazskematky.cz/bezpecne_cesty.php). Day without car (from 1991) and mobility weeks running every year.

E / Day without car is celebrated in big cities of Spain, but there is no campaign motivating citizens to follow it.

F / Pedibus (walking buses), firms travel plans (Grenoble is very active in the field).

NL / Car-free Sundays in the framework on the Week van de vooruitgang – initiative (Week of Progress), that is supported by 10 associations and foundations that operate on the national level. The number of involved cities has grown substantially over the years. In 2009 the inner cities of Amsterdam and Utrecht were totally car free.

PL / City games (thematic walks) organized by private companies for integration of the members of a company (www.grymiejskie.guide-warsaw.com). Spacerownik (Warsaw walks), thematic saturday walks organized by the newspaper Gazeta Wyborcza. Day without car is organized every year.

UK / School travel plans, walking buses. Lots of company travel plans (see for example: www.leeds.ac.uk).

6.3. Services helping moving on foot (and public transport)

On-line shopping or delivery services can help non-motorized people coming on foot or with public transport, or motorized people to walk or use public transport instead of car trips.

In Switzerland a delivery service (using electric bicycles) was developed through the pilot-program "Model city for pedestrians and cyclists", in Burgdorf (13'000 inhabitants), aiming at reducing car use through promoting walking and cycling: the evaluation after five years showed 21% less car trips, 18% more bicycle use and 3% more walking. (www.burgdorf.ch > Umwelt > FUVEMO). In Geneva Caddie Service (www.caddie-service.ch) was created in the frame of an appeal procedure against the construction of a shopping center. It is now going to be developed for the new IKEA in Vernier (home furniture).

In Austria various organizations offer delivery services, e.g. big supermarkets, restaurants, etc. These services do not aim at reducing car use, but they might have some effect on the modal split. These services have never been evaluated. The transport service of the "Reparatur-Netzwerk" (repairing network) won a mobility price in 2009: they offer a transport service of broken devices from home to the respective enterprise to a very low price (5-15 €).

Delivery service in Burgdorf (CH): this service was developed in the frame of the Model City for Pedestrians and Cyclists, it allows coming on foot instead of car travel. The service uses electric bicycles produced in Burgdorf (Flyer).

6.4. Technological innovations which can help

Some processes can contribute to rise the pedestrian status, be it through "accessorizing" and/or accessing virtual realities in the city through bodily plug-ins (mobile devices, wearable and such) or devices plugged into the tissues of the city itself (screens, interactive terminals and so on) giving rise to what is now commonly called the "enhanced pedestrian".

The development of such devices comes mainly from economics and marketing. It can for example give the possibility to localize oneself, and to have access to (more and more) services and information through the internet (see iPhone). This is not specifically useful for pedestrians, but as devices are light, it can particularly help. It is partly replacing more traditional way to get information, such as guiding, city plans, public transport timetable,… For now at least, the access to such devices is probably limited to people sensitive to a trendy technology, particularly young people, but it could change.

In a more traditional way, one can also think of developing accessories that can help to transport heavy things, such as rolling suitcases or shopping bags.

In another domain: it is important to mention the design of a prototype on automatic detection of conflicts at pedestrian crossings, developed in Spain by the Superior Centre of Road Safety Education and the University of Salamanca.

7. Lobbying and relaying structures - help to make it happen

7.1. Pedestrian associations and sustainable transport organizations

Pedestrian associations, organizations supporting environmental friendlier transportation in general (including walking actions as well) or associations promoting "more livable streets" have a key role to play in information, and in raising public and political awareness. They often bring innovative point of views and a more independent way of thinking. They also can be a relay between population and authorities, particularly to support the needs of vulnerable people on foot (old people, children, disabled people).

Pedestrian associations exist in most countries involved in COST 358, being national associations (some with regional sections), or local organizations (most often in big cities). Some exist since 20 or 30 years (Fussverkehr Schweiz in Switzerland was created in 1972, FUSS e.V. in Germany in 1985), some are quite recent (walk-space in Austria created in 2008). Financial resources can only be members fees for some of them, or can be more important when financial support is provided by the government for assuming some charges.

Engagement and activities may strongly vary depending on the situation and the country. In some countries associations played an important role in early research on pedestrian and walking, and they still contribute to communicate information and knowledge through newsletters. Some pedestrian associations get a growing professionalization and are recognized as expert or skills resource in the field. They may take position in law or norms modifications, bear studies in the issue. They initiate actions or campaigns promoting walking (walk to school), organize conferences on the issue, and are sometimes requested to give advice in local pedestrian plans or works.

In Belgium and France, the commitment of associations has been crucial in the process of "Code de la Rue" (Street Code), in collaboration with official structures (see: www.ibsr.be, www.certu.fr, http://velobuc.free.fr, www.ruedelavenir.com). The Swiss pedestrian association played a key role, lobbying in order to introduce firstly, a specific article in the Federal Constitution (voted and accepted in 1979) and secondly, to create a law on footpaths (*in force* since 1987). These represent now the official base relevant at the national and local levels.

Pedestrian associations (from available information):
UK / Living Streets www.livingstreets.org.uk
F / Droits du piéton www.pietons.org
A / Walk-Space www.walk-space.at
S / Fotgängernas förening FOT www.fot.se
D / FUSS e.V. www.fuss-ev.de
CH / Fussverkehr/Mobilité piétonne www.fussverkehr.ch
E / Catalunya Camina
(No specific associations in : NL, P,…)

7.2. Organizations and associations defending the rights of disabled people

In many European countries there are laws concerning disabled people since about 2000, and there is a relatively strong lobbying from associations in projects. On one hand it contributes to reinforce the image of pedestrians as (pitiful) vulnerable users, but on the other hand it allows implementing many projects. It seems sometimes to be the most efficient entry in implementing measures to promote walking, and livable streets for all.

7.3. Health organizations

Coming at the origin from Northern America, there is a growing importance in European countries for health issues in this debate. Some health organizations are interested to collaborate in actions for exercise through “human powered mobility” in an everyday life context (walk to work, to school, or walking for leisure activities). Some research has been developed on the issue, and partnership is emerging between health and planning circles (see for example Health Enhancing of Physical Activity HEPA in Switzerland: www.hepa.ch).

Action of the Health League in Lausanne in the frame of the inauguration of the new metro line: “Métro-maison, le premier kilomètre” (metro-home, the first kilometre). Maps are posted at each stop, showing what can be done on foot distance (15 minutes) from the stop.

7.4. Parents associations, district associations

The mobilization of inhabitants is often the initial stimulus at the source of improvements of the pedestrian situation, often regarding children safety issues and the way of living in the district.

In Lausanne, a district association obtained to transform a zone 30 (30kph zone) in an “encounter zone” (20kph, priority to pedestrian). Official inauguration, with district inhabitants and members of the Municipality and of the administration.

7.5. Administrative delegates and services in charge of the issue

A specific person or service in charge of the issue into the community administration itself can be a very good leverage to integrate pedestrians’ needs in projects, and lobby into the services. An OECD publication regarding cycling ("Villes cyclables, villes d'avenir", 1999) put it as a determinant measure to promote cyclists needs. Nevertheless effects highly depend on financial resources, time dedicated and skills of the persons involved (example mentioned: there is a pedestrian-coordinator in the municipality, however without any budget for research work or other pedestrian issues nor any special competences).

In Switzerland, the Federal Road Office created a structure specifically devoted to human-powered mobility. Though it remains rather small, it is significant that at the federal level the issue was judged fundamental enough to justify dedicated human resources. This structure plays an important role in supporting research and publications in the field (www.mobilite-douce.ch).

8. Conclusion

Walking merges as a theme of interest out of specialized circles or isolated initiatives since about 2000, by virtue of the new paradigmatic approach of "sustainable" development. Undoubtedly, this approach leads to redefine priorities in a favourable way as concerning the ecological use of the city. Leaning on publications, research programs, colloquiums and some pilot projects, the virtues of walking are by now European-wide recognised from the point of view of the environment, the public health, the organization of the city, the quality of the interpersonal relations or the social equity.

Policies concerning pedestrians always seem to begin with road safety policies. Safety issues figure prominently in the literature and, through the media, safety is an essential topic to justify policies in favour of walking. At the same time it tends to limit the perception of the pedestrian as a vulnerable user only, and helps maintain a negative and discredited image among the policymakers, the practitioners and the population.

However, road safety is an interesting leverage to focus the interest on the non motorized users and it is undoubtedly a way to improve the quality of the public space, through European-wide debates and dissemination of practices, notably about:

- The improvement of the crossings (realization, definition of the priorities);
- The implementation of traffic calming measures (shared spaces, zones 30, generalized or zonal limitation of the speed in town) in order to provide a better conviviality and safety;
- The improvement of the accessibility for the less valid persons. Laws on disabled people in many countries (since 2000) accelerated undoubtedly the renewal of the public realm in favor of pedestrians ;
- The question of the walking as a vector of public health for the oldest or of social emancipation for the youngest. Health organizations as well as youth's protection associations also seem to be more and more involved in the promotion of everyday life movement, becoming important partners and supporters for promotion of walking and pedestrians issues.

These recurring debates and dissemination processes are favourable to the emergence of a common technical-administrative culture doubtless globally beneficial for the pedestrian as far as it imposes a perpetual upgrade and therefore, a homogeneous qualitative improvement of the practices in all the countries of the Union. However, the process of homogenization may, in certain cases, slow down the innovation and impoverish the rich variety of the answers supported by a local militant lobbying which feeds until now the process of recognition of the pedestrian among the other users of the public realm. The standardization of the procedures, doubtless desirable under certain aspects, risks also to divert a part of the debate on institutional questions remote from initial demands (the debate on the reintroduction of physical "separations" in the shared spaces is rather symptomatic in this respect).

Urban development also remains a major issue for walking (density, mix use, urban quality). With urban sprawl, long distances that can be covered only by car, low density and bad public transport connection, poor public space quality, it is more difficult or impossible to imagine seriously the promotion of walking.

Research on pedestrian is developing, covering new approaches of the issue. However there is a large potential of unexplored fields, particularly those that can enlighten another image of walking and pedestrian in a “positive way” (not only vulnerable or little distance user) and in articulation with other travel modes: pedestrian at the core of mobility (see for instance RATP project in France). Pilot projects play an important role for the themes’ visibility.

As said here above, policies and strategies in favour of pedestrians are implemented through numerous projects and actions, which is very stimulating. Nevertheless, the projects lean still too often on generic objectives which take the shape of incantations on the necessary transformations of the city and the systems of transport which irrigate it.

Few programs are thus objectively evaluated both as for their real effects on the satisfaction of the users or as for their adequacy regarding the initial objectives. The cases of good practices found in the literature are therefore not enough informed from this point of view and, consequently, remain relatively unreliable concerning the relevance and\or for the efficiency of the allegedly brought improvements. Though difficult, such an evaluation is still a “missing link” requiring steady efforts.

In synthesis, research, education and training on pedestrian issues still need to be improved and require renewed knowledge and competence if we want to keep the benefits gathered until now. Indeed:

1. Walking paradoxically suffers to be too natural or too evident and is still too often only a substitute by default or a complement to other means of communication, even a simple tool used by transverse policies (environment, health). A more radical development of walking as an autonomous system fully adapted to our cities collides therefore very often with the absence of specific investment, particularly in the outskirts or at the fringe of the big cities centres where objectively big efforts were already undertaken and where at present the problems rather recover from the detail.
2. Walking is by definition a non profit activity. It fits therefore with difficulty into a classic economic process which would legitimize it "naturally" within the context of our trade based society, to the contrary, for example, to a product as the automobile. In these conditions, the development of walking is fully dependent on voluntary policies themselves supported by a committed, creative and convincing (as concerns the benefits potentially generated) lobby group. If this lobbying runs out, and if, for example, the environmental answers of the other systems of communication seem more relevant, we are afraid that at present that the favourable socio-political conditions will also be modified.

First of all, interest in the issue has to be raised among practitioners and future practitioners, through basal education and postgraduate courses, to acquire knowledge and finally raise awareness of the topic, in its full relevant and pregnant reality.

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The list of publications is too long to be mentioned here in details: see in country reports, which can be downloaded on www.walkeurope.org.

The walking environment design: indicators and measures.

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'Men and not buildings make the city'
Thomas Fuller

Summary

This chapter, after a brief introduction that puts the issue in the broader context of functionality needs, gives some indications on how to face the design of the walking environment.

The first section of this chapter deals with some essential indicators devised both for evaluating the current urban situation and for guiding choices to be made in the design of a pedestrian environment, meeting users' needs and expectations as much as possible. After that explanation of the role of the indicators and the reason why it is worthwhile to make use of them, it is reported how the indicators for the walking environment can be connected to the Common European Indicators related to urban sustainability, and in particular to sustainable mobility. The core of this part of the essay concerns the choice of the specific aspects such indicators have to govern and the description of the proposed ones, that points out briefly only their most important features, as the definition and the meaning, the main goal and the reference values for the assessment. Five indicators have been chosen because these seem to be the most appropriate to the matter at hand; they are related to the basic requirements/performances of accessibility, safety and use. As an example of the catalogue that was developed in other research studies, the form related to one of them is reported.

In the second section, the chapter deals with some measures devised for improving the walking environment as regards the accessibility and comfort requirements: the former has been chosen since it is the basic condition for enabling pedestrians to use the urban spaces, the latter has been chosen since it represents an ever-increasing exigency, consequent to urban pollution problems and to climatic changes. Also in this case, only some of the available technical measures are outlined: as regards accessibility, they are related to some of the indicators previously described. It explains then the importance of space's accessibility for performing the various activities and of comfort strategies for improving the walking environment, mentioning which are the most important measures to implement. Moreover it describes briefly each measure, pointing out its main aim, some technical specifications and a comment on its efficacy. This section closes with some notes on the main characteristics of the materials used for the construction, always referring to accessibility and comfort requirements.

1. Introduction

As already said in the summary, this chapter presents tools, solutions and measures, to be applied at design level, that are thought to be appropriate both to the pedestrians' needs and expectations and to the urban environment propositions. These two different aspects, both leading, constitute the demand and offer that are read by experts with technical and social backgrounds. When demand and offer do not meet, or do not meet in an appropriate way, it is necessary to act in order to bring back equilibrium. To this aim it is possible to individuate the best feasible uses of the spaces, the necessary adaptations to make them fit and, once defined the corresponding alternative solutions, to sift them in order to define the most suitable technical or non-technical measures to apply and, finally, to evaluate and guarantee their congruity with pedestrians' expectations and with environmental quality on its whole. This is the design process that should be used for devising an appropriate walking environment.

Lists of requirements and performances can technically represent what pedestrians demand and what the urban environment offers. Such requirement classes are built on the basis of the pedestrians' fundamental needs and expectations, as come out by literature studies and enquiries run in previous researches. The main requirement classes concern: accessibility, related to transport, means and network, and to infrastructure; safety related to the use of the urban spaces and to the interference with other transport modes; security; usability; comfort/well-being; appeal, related to aesthetics; sociability, related to the liveliness of the urban space; management, related to cleanliness and upkeep; integrability, related to flexibility and possibility of change. Finally, since in designing an urban space appropriate to pedestrians' requirements is imperative to follow principles and criteria of sustainable development, in order to obtain safer and healthier, more user friendly and appealing cities, the environment safeguard is a must.[1]

Indicators and measures represent two subsequent steps of the design process; the two sections of the paper give insights on how these steps can be faced.

The results here reported come from the research that was made by the authors in various institutions, at different times. As a consequence the proposed indicators and measures, based on some of the listed requirement categories, sometimes refer to different requirements and therefore are not always directly related.

2. Some essential indicators related to pedestrians' basic requirements (Lucia Martincigh)

In facing the design process mentioned before, there is a prior step that can help to make the most advisable choices considering both the demand and the offer perspective: a *trait d'union* between the present and the future situation. Once that all the needs are well known and listed, the requirement classes defined and prioritised, some tools turn out to be very useful indeed to decide which is the most suitable way to meet them: they are the indicators.[2]

[1] The definition of these requirement classes is also related to the one made by UNI (Italian National Standardization Body) Norm 8289: Building, End user requirements, Classification.

[2] Indicators (that are somewhat different from indexes) have been devised and started to be used to describe and try to evaluate phenomena that are not easily directly measured. They are tools that define more aspects at the same time and represent synthetically those factors that allow defining a given phenomenon.

2.1. A tool for evaluating and improving the walking environment

Indicators can be a good tool both to evaluate the existing walking environment and to give suggestions for policy and strategies to apply for improving it, or to guide planners and designers for making interventions when and where the requirements of the pedestrians are not met. Indicators can indeed be used both as check tools of the existing situation and as proposing tools.

The indicators lead the choice of the technical and non-technical interventions to realize, prioritise them and, as their name itself states, “indicate” what to do in the subsequent phases of the design process.

Each indicator that foreshadows general solutions can then be supplied with implementation measures, among which to choose the most appropriate ones to the local situations. In this section of the chapter I will focus on some indicators that are considered “essential” because they are related to basic requirement/performance classes; I will not deal though with the various measures that were directly connected with them in a research of which the author was responsible.

2.2. Indicators of urban sustainability and of sustainable mobility

For evaluating the most suitable choices, it is important to individuate environmental indicators that are apt to define on the one hand the increase or decrease of the level of users’ quality of life, on the other hand the increase or decrease of the quality level of the built environment, considering the mutual influence of the two aspects. To this aim it is possible to refer to the already existing common theories on indicators, which can be adapted to the specific issue at hand, and in particular to some experiences already made in previous European researches on mobility and environment sustainability.[3] Within these programmes it was acknowledged the extraordinary importance of the non-motorized transport modes, in connection with the use of public transport; it was acknowledged also that, for promoting these modes, it is necessary, at the same time, to limit, or re-organize, the private motorized transport modes by the implementation of traffic calming and, in consequence, to improve safety.

To assert in practice the principle of sustainability, it is fundamental to measure the impacts that urban activities cause. The measurement is made by various types of indicators and in particular by those so called of urban sustainability. This principle is contained in the Aalborg Charter[4] that is by now undersigned by about 2.000 European local authorities. In the white book on Governance is underlined the role of the indicators, as tools for decision processes, for monitoring, for transparency and communication. Then, the definition of the indicators for the matter at hand needs to be linked to this more extensive sustainability strategy that is quoted in EU acts and documents. In particular, one indicator among the ones considered in the Common European Indicators project[5], is taken as reference for the definition of the specific indicators related to sustainable mobility and in particular to pedestrians mobility: A3 – Local mobility and passengers transport.

This mandatory indicator analyses the mobility of citizens who live within an area pertaining to the local authority; it is therefore appropriate for analysing the mobility at pedestrian scale.

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[3] Among the others the researches inserted in the LUTR cluster (Marshall & Banister, 2007) and in particular the ones mentioned at Note 6 e 7.

[4] Charter of European Cities & Towns Towards Sustainability, as approved by the participants at the European Conference on Sustainable Cities & Towns in Aalborg, Denmark on 27 May 1994.

[5] The Common European Indicators Project has been launched in 1999 with the constitution of a work group on sustainability indicators (on the initiative and under the supervision of the Urban Environment Experts Group and coordinated by the French Ministry of the Environment).

Being a synthetic indicator, the various aspects related to people's daily displacements, which are considered within, have been used to make clear and to systematize the specific indicators that will be described ahead. Walking is a transport mode that requires a comprehensive strategy, not only at district level but also at urban level; this type of activity falls within what the EU calls thematic strategy on urban environment for which a green book was written. Referring to this strategy, and as regards the goals of a sustainable urban mobility, it is possible to hypothesize correlations among the A3 indicator, above mentioned, and other indicators, both mandatory (A) and optional (B), as e.g. with A2, A5, B1 and B3 indicators, that concern, in order, the local contribution to the global climatic change, the local air quality, children's home-school trips and acoustic pollution, for considering the potential synergies and consequences.

The process that has been followed for defining the specific indicators for the walking environment has led to propose a development in two stages, that could break down in different ways depending on the type or scale of the field object of action, and to determine possible reference ranges: urban, proximity, district and street. The stages concern the singling out of the locating parameters that represent the basic aspects characterizing the actions as regards pedestrian mobility. In the first stage, on the basis of the detected pedestrians' needs and expectations, potentialities and lacks of the actual situation in the considered area and in its surroundings, are assessed; in the second stage the assessment concerns the impacts of the changes made to improve walking: increase or decrease of the performance level of the built environment, from the point of view of pedestrian mobility. Such evaluations are made using specific indicators of state and of transformation; they are therefore the ones to be considered.

Such indicators can be also used in the in-between stage, the design one, to guide appropriate choices for interventions imbued to pedestrians' needs and requirements.

2.3. The urban space characteristics related to users' needs

The choice of the specific aspects the indicators have to govern is related to the concept of sustainable mobility, considering as a starting point the Common European indicators specified before, concerning local mobility and passenger transport.

Mobility, as every other urban activity, is qualifiable in relation to its impact and thence, to be sustainable, it must guarantee a shrewd use of land (interferences among different functions can cause physical, visual and psychological invasion) and of non-renewable sources, it must produce the minimum possible pollution (air, noise, vibrational and visual) and must assure the maximum possible safety to vulnerable users. Moreover, a mobility system to be said sustainable must guarantee to every user, apart from the transport mode she/he uses (non motorized or motorized), a diffuse and fair accessibility, equal right of use and appropriate performances; in particular it has to enable everyone to reach the various attraction poles without decreasing, at the same time, the other performances that the street environment has to offer, among which safety, comfort and appeal. Finally, it has to foster healthier behaviours in citizens' mobility choices.

To this aim it is prior to hierarchize transport modes on the basis of their negative impact on the environment (occupied space, produced pollution and so on) and thence, at the planning and design stage, to favour the ones with the lowest impact.

From this viewpoint, the use of non-motorized transport modes, as pedestrian and cycle, and of public transport means, together with the application of eco friendly solutions, have to be preferred. Attention is then focussed on the issues related to the re-organization and re-balance of mobility in general, revising on the one hand weights and hierarchies of the various transport modes and on the other hand the way of designing the infrastructure hosting them. In this process the infrastructure is meant as a three-dimensional space, where various transport mode users are present, even if with different nuances, and several activities are performed and where, therefore, a multiplicity of features concur to shape the architecture of the "street". In the construction of this new urban environment, the choice of the transport modes and of the technologies for the mobility represent an aspect that is relevant for the quality and liveability of the urban space.

For the reasons mentioned till now, the indicators that will be further described concern the specific aspects related to pedestrian mobility; their devising starts off pedestrians' needs and expectations and is aimed at the design of consequent congruent spaces, specifically dedicated, that offer the highest possible number of required performances.

2.4. Definition of indicators for the walking environment

The choice and the articulation of the indicators are grounded on the research work already run in European (PROMPT[6] and ASI[7]) and in national (PRIN 2004[8]) researches.[9] In these researches work has indeed been going on for the definition of indicators that are related to main requirement classes, considered basic for sustainable mobility, and in particular for pedestrian mobility. These indicators have been also grouped to foreshadow eight different qualitative characteristics of the urban environment, all strictly interrelated, that on their whole constitute the expected urban environment devoted to sustainable mobility (L. Martincigh, 2009).

Of all these indicators, for the sake of brevity, here are mentioned only five of them. They have been chosen among the others because, being related to the basic requirements/performances, they seem to be the most appropriate to the matter at hand. They are indeed considered "essential" indicators; some of these indicators (first level) are further articulated in more specific indicators (second level).[10]

Once that these essential indicators, related to accessibility, safety and use, are applied, it is possible and to be hoped for, that the study is deepened and widened to consider other indicators, concerning comfort, security, appeal, liveliness and so on.

Since the issue at stake is the walking environment, short trips, to be made exclusively on foot, and longer ones, with walking as an ancillary mode, are considered. Attention is then focussed on the features that make appropriate the spaces where people walk and stop as well as the intermodal exchange points and the paths to reach them.

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[6] "PROMPT – new means to PROmote Pedestrian Traffic in cities", coordinator: Kari Rauhala, VTT. http://prompt.vtt.fi

[7] "ASI – Assess implementations in the frame of the Cities of Tomorrow", coordinator: Ralf Risser, FACTUM. http://www.factum.at/asi

[8] "The mobility factor in the reconversion of dismissed areas", theme deepened by the research group of the University of Roma Tre, Rome (I), responsible: L. Martincigh, Department of Design and study of the architecture, in: National research project (PRIN): "The environmental compatibility in the rehabilitation and reconversion project of disused areas coordinator: M.I. Amirante, Department of Restoration and Building of Architecture and Environment, Second University of Naples (I).

[9] The study on indicators has been carried on in a research funded by the Department of Design and study of the architecture, University of Roma Tre, Rome, Italy: "The urban street environment: from devising to construction", responsible L. Martincigh, that is at the moment co-ordinated with COST Action 358.

[10] The former are usually called "indicator categories", the latter "indicators". In the reported research work, up to now, it has been used a tree organization, in which all the indicators are measurable and definite, but a big branch can be broken down to smaller branches that specify more and more the matter. In this way they can be chosen, and applied, depending on the level of deepening that is wanted. They are therefore distinct per level of deepening.

Each one of the five listed indicators, defined as indicator of state and of transformation, is outlined by items that specify not only its characteristics but also the goals and the modes of application; such description shows also eventual transversal relations. The main items, referred to both types of indicators (of state and of transformation) are listed in a form. They are: definition of the indicator (measurable), code, meaning, brief description of the indicator (operational), direct and correlated goals, glossary, unit of measure, indications for calculation and for representation, thresholds values, data sources, up-dating. All the forms constitute a catalogue, started in the research already mentioned and actually still in progress.

I1: Amount of public space devoted to pedestrian mobility, to sojourn and to social relationships

This indicator describes the usability of the spaces devoted to pedestrian mobility, and to its related activities, considering the percentage of space dedicated to it in comparison to the total public space dedicated to mobility in general.

Accessibility, usability and safety of use are indeed strictly related to quantity of space, and quantity works as an incentive to walking at least for short trips. Indeed, a congruous network of pedestrian paths, avoiding, or governing, conflict points among different flows, makes possible the convenient use and the social interaction among users who occasionally meet, and moreover guarantees the commodity and swiftness to a way of moving that is instinctive: walking. If the public space should be insufficient, it is suggested that part of the carriageways and of the services and private areas can be taken, depending on the settlement's density, for increasing such quantity, with the aim of achieving a quantity of space suitable for pedestrians to perform easily their activities of movement and of sojourn.

The indicator I1 is flanked by two more specific indicators, aimed at guaranteeing the characteristics of accessibility of the paths, dedicated to walking, and of the crossings; failing this, the pedestrian network would be inaccessible at least to a certain number of users and would not enable the easy performance of casual activities:

I1.1: ratio carriageway/sidewalk;
I1.2: dimension of multifunctional sidewalk.

The former defines the correct ratio between the areas devoted to vehicular and pedestrian mobility with the aim to increase the space dedicated to pedestrians. The classification of the streets on the basis of reference values becomes an assessment of the situation and indicates where it is necessary to act.

The latter defines the dimension of the pedestrian spaces and paths that enables, besides an easy passing, also the performance of other activities and that allow for higher pedestrian flows. To this aim it considers the quantity of streets with sidewalks wider than 3m. For easing the evaluation of the dimension, specific indications and reference values are given as regards the sidewalk possible organization in functional zones, varying depending on the activities and on the urban areas.

I2: Density of network of pedestrian paths

This indicator gives information on the density of the pedestrian network, which should enable continuous changes of direction and provide alternative paths, suitable to users with different abilities, and shortcuts, attainable considering also a new relation between public and semi-public spaces (courtyards). It is common knowledge that pedestrians choose always the shortest and less tiring way to reach their destination; it is a must therefore to make the reaching of the places of attraction easy, by a continuous, accessible, safe and short route. The density of the network is estimated then considering the distance among its intersections, and using specific reference values.

The indicator I2 is flanked by two more specific indicators, aimed at guaranteeing the continuity and accessibility of the pedestrian paths and crossings, and thus to ensure the service also to the most vulnerable users (children, senior citizens, PMR people and so on).

I2.1 percentage of totally accessible crossings;
I2.2 percentage of totally accessible sidewalks.

The former defines the continuity of the pedestrian network on the basis of the crossing requirements, in order that it is accessible and safe for all the users, regardless of different levels of ability. To this aim it assesses the percentage of accessible crossings as to the total amount of crossings, with the aim of achieving a pedestrian network with no physical, visual and perceptive interruptions. To make easier the evaluation, specific parameters for considering a crossing as accessible are provided.

The latter defines the continuity of the pedestrian network on the basis of the dimensional and morphological characteristics that make them accessible and usable for all the users. To this aim it assesses the percentage of accessible sidewalks as to the total amount of sidewalks, with the aim of achieving a pedestrian network totally continuous and accessible. For easing the evaluation, specific indications and reference values are given for deciding when a sidewalk can be considered accessible.

In both cases, the parameters, suggested for judging if a sidewalk/crossing is accessible, are detectable, countable, measurable depending on the type.

I3: Amount of streets with 30km/h (or lower) speed limit

This indicator gives an idea of the quality of the vehicular traffic flow, defining the amount of streets where speed is compatible with urban liveability. The indicator quantifies the soundness of the supply by calculating the percentage of streets that have a 30km/h, or lower, speed limit, with the aim to achieve, in the residential or mainly residential areas, the threshold value of 100% of streets with such speed limit.

The typology of streets affects indeed very much the quantity and diffusion of walking. Guaranteeing a low speed limit enables pedestrians to feel as a prior component of urban traffic and makes them feel safe in moving around.

I4: Amount of parking areas

It is common knowledge that greater is the parking supply greater is the private vehicular traffic; parking is a traffic attractor. To ease walking, for what stated at I3, it is then proper to control and reduce the parking supply, at least in some sensible areas.

This indicator detects and defines quantitatively the areas devoted to legal and illegal parking (unrequited demand); it determines the optimal quantity of parking areas as to the distance from the interchange points of the public transport system, the use destination, the quantity of dwellers/housing units and/or of other users. To this aim reference values, mostly based on German and Swiss experiences are provided.

I5: Accessibility to the public transport system

This indicator gives a rough indication on the accessibility of the public transport network. Quantifying, locating and “calibrating” the interchange points in the network enables to facilitate the choice of using public transport instead of private ones and, thence, walking in connection with it.

The indicator measures the distance between interchange points in the public transport network. For the system to be valid, such distance has to be appropriate to the different users’ exigencies, so that the network results accessible and the stops can be easily reached on foot.

For evaluating such distance, the effort used in walking is used as parameter as well as best practice.

2.5. Cataloguing of the indicators

Every indicator can be described to specify its characteristics, its objectives, how to apply it, the transversal relations, the measurement ways, the thresholds.

The need to define indicators that are easily applied both at the evaluation and at the design stage has led to define thresholds values that enable to evaluate the consistency of a choice or of a solution. Such values often are not at disposal or are not suitable for the national and/or local situation. The threshold values have been defined on the base of data deduced by literature, case studies, best practice or excellence; they can be represented either by sharp numerical values or by reference ranges.

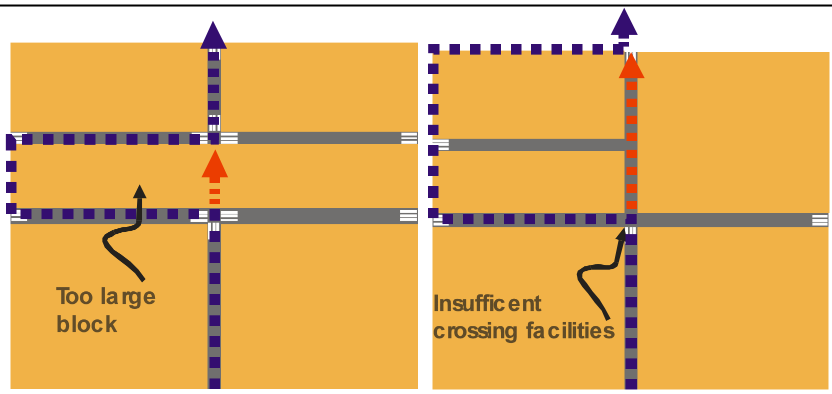
As an example of the catalogue that has been drawn up till now, here is reported the Indicator I2: Density of network of pedestrian paths (Table 1).

2.6. From the indicators to the operational stage

With the application of the indicators, of state and of transformation, it is possible to evaluate the existing situation and to determine the eventual lacks, but it is possible only to hypothesize the necessary interventions and it is not possible to face the operational stage. To this aim it is necessary to define such actions, hypothesizing strategies and solutions consistent with the previous indicators. They can be then broken down in measures that become the tools to be used to achieve the goals prefixed by the indicators. These can be determined by the analysis of literature, case studies, best practice and outcomes of European or national researches. In the researches that were already mentioned some of these measures were analysed and proposed for adoption.[11]

[11] See Note 6, 7, 8 and 9.

Table 1 The form for the indicator I1: Pedestrian network, translated in English to exemplify the catalogue of indicators drawn up for some national researches (see note 5).

Density of network of pedestrian paths	
Indicator of state	Density of the network measured by the distance among the junctions.
Indicator of transformation	The density of the network needs to be very high; the optimal value has to reduce the use of energy to the utmost and, thence, the distances among the junctions have to be reduced to the minimum and the useless detours avoided, even though allowing pedestrians continuous changes of direction.
	 Examples of inefficient pedestrian networks
Code	I1
Meaning	This indicator gives recommendations on the density of the pedestrian network that should allow also for alternative routes, suitable to all the users, and shortcuts, by a new relationship between public and semi-public spaces (courtyards).
Description of the indicator of state	Monitoring of the pedestrian paths and definition of the distances among junctions and of the detour ratio; information on the presence of steep stretches or stairs.
Description of the indicator of transformation	Individuation and definition of the network of pedestrian paths with a density that is optimal to guarantee that the destination is reachable, without useless detours and with alternatives to steep stretches and stairs.
Reference goals	• To ease pedestrian mobility; • to shorten distances; • to allow continuous changes of directions; • to make pedestrian mobility spaces accessible also to people with reduced mobility (PMR).
Correlated goals	• To reduce private vehicular traffic for short distances; • to save energy; • to reduce acoustic, air and visual pollution; • to favour healthier behaviours in mobility.
Definitions	Pedestrian path: portion of the street devoted only to pedestrian flow; Network: continuous and closed grid; Junction: spot that enables to change direction and that can be at mixed use; Detour ratio: ratio between the actual distance and the bee line; Steep stretch: path with a slope exceeding 8%, that constitutes a barrier for motory impaired people.
Unit of measure (Indicator of state)	m/m
Unit of measure (Ind. of transformation)	m/m

Estimate	The density of the network can be assessed measuring the distance between the junctions, i.e. between the possible changes of direction that the grid allows to users, by overlapping a reticular grid to maps in proportionate scale. It has to be controlled also the ratio between the actual path, used to reach the main destinations (for example public transport stops, school etc.) and the beeline, which should be low.
Representation	On the maps, appropriate graphic symbols can represent the network junctions and quantities mark the distances; quantities mark the detour ratios that are too high, colours can point out steep stretches and stairs.
Thresholds	A dense pedestrian network enables users to choose always the shortest path to reach destination. Loose links are the consequence of large building blocks or of insufficient (or bad positioned) crossing facilities. These problems can be solved creating shortcuts, assigning portions of private space to public space and making a methodical observation of users' behaviours. The pedestrian network has thence to be characterized by short links and has to enable users to make continuous changes of directions. Moreover it has to be legible, i.e. designed following a logic and regular scheme. A rectangular grid gives the best orientation also to non-residents, however to the detriment of length: the grid thence can be complemented with diagonal paths. In the urban texture, the standard block, defined from the typological and morphological point of view by Caniggia and Muratori, measures 60 x 108 m. The pedestrian crossings have to be put at a distance of 100 m, as defined by the Italian Traffic Code. On the basis of these studies and norms, the threshold value for the distance between junctions can be fixed between 60 m and 100 m to the utmost. The detour ratio between actual distance and beeline has to be between 1,2 and 1,4 to the utmost, that is a typical value of a square grid. The path must not have steep stretches exceeding 8% and stairs; if it does, also alternative paths or solutions have to be provided for.
Data sources	D.Lgs.285/1992, art.7, New Traffic Code (Italian); Caniggia, G., Maffei, G.L., "Composizione architettonica e tipologia edilizia. Vol.1 Lettura dell'edilizia di base", Marsilio Editori, Venezia (I), 1979; Martincigh, L. and Urbani , L., "WP7: Working out solutions", in: PROMPT (New means to promote pedestrian traffic in cities) coordinator Rauhala, K., http://prompt.vtt.fi
Updating	

3. Some measures to design the walking environment (Chiara Tonelli)

This section deals with the design of the walking environment at the project level, referring to the activities that pedestrians perform in it and considering mainly Accessibility and Comfort requirements. Of course all the requirements described in the Introduction are important to orient the urban space re-design, but these two requirements play a crucial role: the former is necessary to enable pedestrians to use urban spaces, the latter aims to solve the problems related to urban pollution and climatic changes, and is closely related to environmental sustainability issues. The meeting of these requirements considers solutions that are studied taking into consideration "with awareness" the context -both built and natural- in which the design proposals are devised.

The following paragraphs also list the most suitable materials for satisfying the pedestrian requirements of Accessibility and Comfort. As a matter of fact, the design and re-definition of a pedestrian area play an important role not only from a formal point of view but also from a material one.

3.1. Activities in the walking environment

To design the spaces devoted to pedestrians in such a way as to meet their requirements, it is important to understand the activities they wish to perform in such spaces.

Gehl[12] distinguishes between necessary/functional activities, optional/recreational activities and social activities in public spaces. The first, associated with job, study or daily lives, are mainly performed by movement. The second are ones of *choice*. They are performed in one's free time and in a pleasant environment and, normally, without movement. The third, a consequence of the second, depend on the *co-presence* of people in the space. While necessary activities take place regardless of the quality of the physical environment, optional activities depend to a significant degree on what the place has to offer and how it makes people behave and feel about it.

Much has been written on this subject from a dimensional point of view and the dimensional range required by a pavement to provide space for various activities is known.

The German regulation EAHAV93, for example, defines the minimum space required for people to pass, bearing in mind ergonomic aspects and dimensional impediments caused by things to be carried (bags, suitcases, shopping bags, open umbrellas, etc.).

This approach primarily considers the minimum space required to carry out an activity, taking into account that spatial characteristics have little effect on necessary activities.

However, when social space is required in urban areas, the dimensional aspect becomes just a necessary, but insufficient, element. What is more important is the need for special equipment and specific environmental conditions associated with comfort (microclimate, sound, visibility, smells, etc.). In other words, the organisation of space no longer involves just the pavement, but the entire pedestrian network including its adjacent areas – roads closed to the traffic, squares, gardens and city parks. These kind of spaces, to favour social life, require more elements, such as water, vegetation, elements of attraction, furnishing, ….
The better a place, the more optional activities occur and the longer necessary activities last. Social activity is the fruit of the quality and length of other types of activities, because it occurs spontaneously when people meet in a particular place. Social activities include children playing, greetings and conversations, communal activities of various kinds, and simply seeing and listening to other people. Communal spaces in cities and residential areas become meaningful and attractive when activities of all types occur in combination and supply each other.

The type of activities that should be included in a comprehensive vision of pedestrian requirements are therefore the following: walking, stopping and sitting, looking, listening and talking.

As regards walking, based on the indications of the above-mentioned German regulation, we can satisfy these needs by considering the impediments involved in moving from one place to another.

Stopping and sitting is a basic activity that exploits urban space. Even though there are many reasons for stopping or sitting, the three primary ones are: the need to rest, the need to wait (for a means of public transport, a person or an appointment) and the desire to look at the city or meet other people.

All our senses are employed in the perception of the environment, but sight and sound are the most important: when what we see and hear is not perceived as irritating, then this

[12] Gehl, J. (1987); Gehl, J. & Gemzøe L.(1996); Gehl, J. & Gemzøe L. (2001).

creates the minimum conditions of acceptability for active listening and observation. There are many ways in which conversation in public spaces can take place: between friends or between a mother and her child, during causal encounters between acquaintances or strangers: this proves how the possibility to converse is important as an indicator of the quality of the pedestrian space, whether walking or stopping/waiting.[13]

In the light of what is above mentioned, amongst the requirements listed in point 1., we believe it is useful to carefully study several “Accessibility” and “Comfort” requisites and performances that play a key role in the creation of a sustainable urban space, usable by pedestrians. In general it is imperative to guarantee more green and friendly areas without smog, noise and risks in order to favour people’s interaction more than the actual urban areas do. To obtain this environmental quality it is necessary, as already mentioned in point 2. describing the essential indicators, to work on some main aspects, as for example on the design of a continuous pedestrian network, with safe and accessible crosswalks; on the control of speed by traffic calming measures; on the reduction of parking areas to give pedestrians and cyclists more space. Once this first goal is achieved, it is important to work on other aspects that give added value such as the increase of vegetation, both linear and surface, creating a green network, as well as the use of materials, components, and urban furniture, durable and easy to upkeep, that are congruent with local architectural features.

The following sections of the chapter deal with some measures and some strategies necessary to make operational such aspects to meet the two requirements of Accessibility and Comfort.

3.2. Accessibility of the walking environment

In cities, the first space dedicated to pedestrians is usually the pavement. It has an urban function if, on a bigger scale, it is part of a seamless network that respects the following standards of accessibility:

- minimum width 1.5 m for 60% of its length[14];
- no parts less than 90 cm wide[15];
- access points at both ends and at least one every 100 m[16];
- continuity near driveways, etc.[17];
- even surfaces suitable for all users, in all directions[18];
- widening wider than 1.8 m for staying or U-turns[19].

This standard is based on the possibility for person in a wheelchair to use a pavement, to be able to change direction and meet another person. However, it does not take into account all the possible activities that can be carried out in a place where people walk. This standard should therefore be considered as a compulsory minimum and each time the overall dimensions of the road allow, the width of the pavement should be widened to 2 m[20] or more, to make it more user-friendly.

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[13] Goffman, E., 1963.
[14] Martincigh & Urbani, 2005.
[15] Decree of the President of the Republic 24 July 1996, n. 503 «*Regolamento recante norme per l'eliminazione delle barriere architettoniche negli edifici, spazi e servizi pubblici»,* Title II, articles 4, 5 & 6. Decree of the Ministry of Public Works 14 June 1989, n. 236 points 4.2.1, 4.2.2 e 8.2.1, 8.2.2.
[16] Martincigh & Urbani, 2005.
[17] *Ibidem*.
[18] Decree of the President of the Republic 24 July 1996, n. 503.
[19] *Ibidem.*
[20] Dimensional indication also established by Ministerial Decree 5 November 2001, *Norme funzionali e geometriche per la costruzione delle strade del CNR*.

The size of the pedestrian space should therefore be based, as already mentioned, on an analysis of the activities that are, or can be, performed there. The more the activities, the wider the space that has to accommodate them.

As regards the spaces for pedestrian mobility, Italian legislation for the elimination of architectural barriers states the following[21]:

- the drop between the level of the pavement and the adjacent lanes should not exceed 15 cm;
- the width of the pavements in new urban areas must allow use by people in wheelchairs;
- in high-traffic roads, pedestrian crossings must be illuminated at night or when visibility is poor;
- speed tables at pedestrian crossings must be accessible by persons in wheelchairs.

As mentioned above, fulfilling the requirements of accessibility from the pedestrian's point of view does not depend only on the size of the space, but is closely linked to the seamlessness of the pedestrian network. This network must include identifiable spaces of pedestrian "polarisation", in other words with multiple functions that pedestrians can use. A residential environment with several pedestrian areas is certainly more liveable compared to one where there are just roads and pavements. There are different kinds of spaces: enlargement of parts of a pavement, pedestrianisation of entire stretches of road, pedestrian areas, areas shared by pedestrians and vehicles where, however, vehicles are not invasive and their speed is compatible with pedestrian use. When pavements are not present, as in some suburban areas or small towns, one possible solution is the construction of pedestrian walkways, paved with materials different from those used for the vehicle lanes, but placed at the same level and without bollards if there is little traffic and small parking demand.

It is important that the pedestrian network not only ensures the pedestrian's "safety" when using the network, but also creates the right conditions so that people can enjoy the social and aesthetic aspects of the urban space. In actual fact, vehicle mobility seriously hinders the possibility of urban vitality and, in agreement with Gehl, we can identify three main effects:

- the presence of cars remove people from public spaces[22];
- the presence of cars reduces human activities, because weaker users, i.e., old people and children, have less freedom to afford the public space;
- the presence of cars changes the landscape; on the one hand because moving or parked vehicles negatively affect the aesthetics of an urban area and, on the other hand because, when seen from a car, the urban architecture appears to be homogenous and ordinary due to the speed with which it is observed.

These effects and the need to create a seamless network provide an opportunity to introduce traffic mitigation systems especially in residential areas.

3.3. Traffic calming measures related to the pedestrian network

As already mentioned, the goal of all traffic calming measures[23] is to reduce speed on the roads in order to create more liveable areas - safer, less polluting and less noisy.

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[21] Decree of the President of the Republic 503/1996, *Regolamento recante norme per l'eliminazione delle barriere architettoniche negli edifici, spazi e servizi pubblici*.

[22] In residential areas to put parking areas in apartment garages hinders the development of social relationships in the street. In these specific situations it is better to create parking spaces in the street or communal garages walking distance from the houses.

Extensive literature, legislation and regulations exist on this subject. Therefore in this paragraph we chose to focus on those measures which act as an interface between the pedestrians and the road network, contributing to create polarised pedestrian spaces. In this sense, to increase use by pedestrians and attract new social functions, a minimum intervention can be made by placing chokers on the road, that widen part of the pavement.

Such pavement extensions can also be built at bus stops or public transport platforms, facilitating the connection between the stop and the pavement.

Another kind of polarised pedestrian space is constituted by speed tables. They are one of the strong points of Speed Zones, in which the concept of "pedestrian crossings" is replaced by "vehicle pavement crossing". At each intersection the use of raised speed tables obliges vehicles to "go up on the pavement", in other words to invade an area where the pedestrian has right of way. They can be used in front of public buildings or buildings that attract a high number of people (schools, hospitals, parks, etc.) or in residential areas, since they slow down vehicle traffic.

Finally, street closures are an opportunity to revive entire urban areas and give more liveability to the entire district.

The measures described below are linked to the indicators in section 2., indicating operative measures that explain the solutions proposed.
For each measure we list the description, the aim and the technical specification. Sometimes, if useful, the measure efficacy is provided.

Chokers and pedestrian refuges

Description The narrowing of lanes can be achieved by widening the pavement on one or both sides of the street, in general by using curb extensions with or without pedestrian crossings, or by introducing a pedestrian refuge or small island in the middle of the street. Chokers function as a way to slow down traffic since they break up long straight stretches of road. When they are placed in two-way streets, they can also reduce two lanes to one: this forces vehicles to slow down almost to a standstill to let vehicles coming from the opposite direction pass. This measure can be gainfully applied to large speed tables with intense pedestrian flows.

Aim This measure is used to produce more of a psychological rather than physical effect on the driver, because often the narrowing of the lane is not enough to drastically reduce speed.

From the pedestrian's point of view the choker reduces the length of the pedestrian crossing and provides more space for pedestrians along the road.

Technical specifications Curb extensions can be created either by eliminating parking spaces or by narrowing vehicle lanes.

The size of the curb extension depends on the residual width of the lane. Opinions diverge on this point.

DETR_UK prescribes that chokers and islands should not narrow the lane to less than 3.5 m.

[23] Humps, chokers, chicanes, raised speed tables, changes in the pavement, … .

Instead, for two-lane streets the French CERTU advises the introduction of alternate directions, leaving vehicles a less than 3 m space, and for one-way streets, a space of 2.5 m (possibly with an area partially usable by public transport).
As concerns chokers, the CERTU prescribes they should be approx. 1 m wide and 5-10 m long, narrowing the lanes to 2.5 m.

One type of pedestrian refuge has cordons or staggered curbs used to direct pedestrians and ensure they do not cross without paying attention to the traffic coming from both directions.

Efficacy Because chokers and islands are not very effective in reducing speed, they should be used with other vertical traffic calming methods, in particular, raised crossings: facilitating pedestrian crossing can be achieved using chokers in one-way streets because they reduce the confliction space between pedestrians and vehicles, and by refuge islands for two-way streets, because they allow pedestrians to watch for traffic from only one direction.

Speed tables at pedestrian crossings

Description A raised pedestrian crossing is a raised flat area covering the entire space of the intersection between opposite pavements that reduces (or sometimes even eliminates) the difference in level between the lane and the pavements, ensuring the continuity of the pedestrian network and eliminating barriers (i.e. the curb step).

Raised pedestrian crossings are always accompanied by a curb extension in order to produce a narrowing of the lane (choker) and stop vehicles from parking near the intersection.

Aim Raised pedestrian crossings provide continuity of the pedestrian network, help to make pedestrian crossings safer, reduce the speed of transiting vehicles and reduce accidents for vehicles and pedestrians as well as for the cars themselves.

Technical specifications Dimensional characteristics of the crossing:

- height: 10 cm (DETR - UK);
- slope of the ramp: approx. 5-6%(DETR - UK);
- minimum length: greater than that of normal vehicles and, if public transport is involved, greater than the wheelbase between the front and rear tyres of heavy vehicles (Ministry of Public Works – Italy, CERTU - France);
- length-height ratio: length less than 10 m, maximum height 10 cm; length more than 10 m, height between 10 and 20 cm (CERTU - France).

In deciding the right height, one must consider the need for continuity of the pedestrian network; the greater the height of the speed tables, the shorter the length of the ramps to the pavements: from this point of view, 10 cm is a good compromise.

In France, there is a sign before the speed tables introducing a "pedestrian zone" considered as an area in which pedestrians have right of way and cars can only circulate at a crawl. Pedestrians can freely cross the intersection in all directions, even diagonally, without the need for zebra stripes. Raised pedestrian crossings are marked using a paving that is different from the colour or material used for the street or with symbols (e.g., stylised pedestrians).

It is important to envisage a correct design of the slopes of the speed tables and positioning of the drains, to avoid water stagnation at the intersection.

Street Closures

Description The closure of a street means implementing measures to stop vehicles entering from one end and exiting from the other end. The closure can be:

- **total**, when vehicles are not allowed to enter or exit that portion of road. In this case an area for pedestrians and cyclists is created allowing access only to emergency vehicles, delivery vans and vehicles transiting to access their property. Vehicle access is ensured by removable elements – for example retractable bollards – at one or either ends of the street. Total closure can be instituted during certain hours of the day (e.g., when children are going to or leaving school or for periodic events,…) and left open for the rest of the day;
- **partial**, when vehicles can access the street but must exit where they entered. This is called a cul-de-sac and can be designed using the *woonerf* or *Home Zone*[24] model. Furniture, play areas, hedges, benches and parking areas have to be arranged so that the vehicle lane disappears.

Partially or totally closed areas include those where the redesign of the public area of a street can produce a substantial improvement in the aesthetics of the urban landscape. These areas contribute to creating a new vision of urban liveability. We must however emphasise that, on the one hand, total closures should be used in situations that will attract the public, for example if certain conditions exist: natural elements, hotels, commercial activities – either present or to be created – especially restaurants. But on the other hand the street closure measure could be applied in residential areas in order to create safe and equipped areas for children, old people and other weak users.

Aim The aims are:

- to limit the traffic flows crossing the district;
- to create highly livable spaces in the streets or portion of streets that are closed to vehicular traffic;
- to create pedestrian spaces near buildings with services or functions that attract a large number of people (schools, hospitals, museums, cinemas, churches, etc.);
- to create "road-squares" that act as commercial hubs for the district or as safe play zone for residential areas.

Technical specifications There are no compulsory technical specifications for street closure. However, before applying such measure, it is necessary to study its impact on vehicular traffic.

Efficacy The closure of roads emphasises the multi-functionality of the road in favour of pedestrians, children's playgrounds and social interaction. Pedestrian-only areas reduce the differences between able-bodied and physically challenged persons.

3.4. Comfort of the walking environment

There are many kinds of sensorial comfort: thermal, visual, acoustic, tactile, olfactory, respiratory and hygienic. It involves active and passive adjustment to different environments. The perception of the environment can be quantitatively measured (physiological response) but it is a subjective and cultural element that is difficult to measure.

[24] See for the Home Zone the publication IHT - The Institution of highways and transportation, (2005) *Traffic Calming Techniques.*

Although all these parameters contribute to the overall well-being of the pedestrian in space, microclimatic parameters[25] determine the use of urban spaces. In fact, reactions to the microclimate can be unconscious, but very often induce a differentiated use of open space depending on climatic conditions. For this reason, comfort is considered as:

– physical well-being, involving climatic factors and microclimatic conditions, caused by forms and functions of the urban environment (buildings, green areas, water, type of mobility, spaces, uses, ...);
– psychological well-being;
– convenience when moving or stopping, while using space in different ways.

The variables that characterise the microclimate at different times of the day and the year are:

– solar radiation,
– air temperature,
– relative humidity,
– wind speed.

However, although the environmental parameters influencing the conditions of external thermal comfort are similar to those of internal spaces, they are more numerous and variable. In fact, design solutions compatible with the context in which the measure has to be implemented must be based on the study and interpretation of the buildings and natural (morphological and material) elements of that context as well as on their relationship with adjacent open spaces and urban surroundings.[26]

The evaluation systems developed for different geographical areas allow assessment of the microclimatic behaviour of a place. It is therefore possible to use certain factors to modify the effects and interactions they cause to the thermo-hygrometric, acoustic and atmospheric environment. However, a thorough examination or assessment of these methods is not part of this paper.[27] The following paragraph therefore focuses on several design strategies that can be generalised for temperate climates and be used to support some design choices.

3.5. Some comfort design strategies for the walking environment

This paragraph focuses on a list of some more common design strategies that can be used in the requalification and redesign of urban space. In temperate climates, these strategies contribute to enhancing environmental comfort as regards thermo-hygrometric, acoustic and air quality factors as well as reducing annoyance factors.

However, generalised solutions to the problem will only affect certain choices, because it is the design and analysis of the specific characteristics of a place that can establish the actions best suited to solve the problem. In fact, the objective of the requirements, indicators and measures is to support the drafting of the project in a performance-oriented rather than prescriptive manner. The strategies are therefore illustrated only to exemplify possible solutions to the more common problems.

[25] The urban microclimate is an atmospheric situation within the urban framework that causes inhomogeneous conditions for a person at a distance of 150 m.
[26] See Grosso, Peretti, Piardi & Scudo, (2005), pp. 109-128.
[27] For more information about how to measure the urban parameters that influence the microclimate, see Nikolopoulou, M. (editor), (2004); Grosso M., Peretti G., Piardi S. & Scudo G. (2005); Dessì, V. (2007).

One should also remember that the solution to one problem might lead to other problems. For example, although a light-coloured and solar reflective material for a floor is an excellent solution for the summer months because it limits absorption and ensuing release of heat, the glare can be visually uncomfortable. Only by reviewing and examining all these aspects is it possible to identify the strategy that best meets all the requirements.

Concerning thermo-hygrometric comfort, during the summer it is important to regulate direct, diffused and reflected solar radiation, reduce the temperature of horizontal and vertical surfaces, create air flows through natural or artificial deviators that direct the wind especially towards outdoor spaces normally used in the afternoon. On the contrary, in the winter sunlight should be available and natural or artificial barriers should help to defend against the wind.

The choice of the paving materials, furnishing and vertical coverings cause significant variations in surface temperature which is influenced by the irradiation of the surfaces and by variations in the emission coefficient as well as by the material and surface colour and the way in which the surface is treated and used.

Mobile screens play an important role in preventing overheating during the summer and increase winter irradiation. However, the amount of shadow areas depend on the form and size of the screen and the quality of the shadow depends on the screening material.

Vegetation plays an important role in climate control by providing shade and coolness thanks to evaporation, by channelling summer winds and by acting as a barrier for winter winds. In the same way, during the summer, all kinds of water– lakes, fountains, cascades - cools down the air.

Vegetation and water play an important role in mitigating acoustic pollution, one of the main factors of deterioration of urban areas.

When automobile traffic is the source of the noise, apart from using sound absorbent materials for the roads, it is possible to implement speed reduction measures or discourage the use of private transportation. To reduce speed, different kinds of traffic calming measures should be implemented together.

To increase acoustic well-being in mainly pedestrian areas, it is possible to use sound-absorbent barriers near the noise sources, to put vegetation screens and narrow the carriageways.

When comfort depends on air quality, possible sources of pollution should be identified - for example, factories, industrial discharge, high density road networks - to assess the possible effect it may have on pedestrian areas. These measures are obviously “passive”, i.e., they do not affect the source. They consist in trying to place newly designed pedestrian areas upwind compared to the polluting sources and far from the canals of the polluting agents (after studying the direction of prevailing winds). Generally speaking, they include the screening of the air flows that could carry polluting substances either by introducing vegetal barriers made of bushes or shrubs – effective in fighting pollution – or artificial barriers.

Instead when car emissions are the main atmospheric polluting agent, it is important to reorganise vehicle traffic, creating a safety zone between the road and recreation areas as well as introducing trees that can act as filters.

As outlined above, the design and redefinition of a pedestrian area plays an important role not only for the shape but also for the material nature of any particular place. This is why the following paragraph lists the materials for urban space most suited to satisfy the requirements of Accessibility and Comfort of pedestrians.

3.6. Materials of the walking environment

With reference to the accessibility requirement and according to the *New Zealand Pedestrian Planning and Design Guide*[28], all surfaces on which pedestrians walk should be firm, stable and slip resistant[29] even when wet. Sudden changes in height on otherwise even surfaces should be less than 5 mm. To minimize stumbling hazards, undulations in otherwise even surfaces should be less than 12 mm.[30] This also prevents puddles from forming. Dished channels for drainage should not be incorporated within the through route.

Considering the paving materials it is important also to take into account the way in which they are laid. In fact «short, sudden changes in the surface, such as single steps, should be avoided as they are unexpected and can cause pedestrians to trip or catch the front wheels of wheelchairs and baby carriages».[31] The footpaths have to be as simple and regular as possible compared to the main access routes and without bottlenecks, furniture or obstacles of any kind that reduce the width of the passageway or can cause injury/accident.

«Concrete and asphalt are generally considered the most appropriate footpath surfaces, although stone pavers and unglazed brick can also be used. Material combinations are possible, such as a concrete through route edged with unglazed brick to provide visual contrast for vision impaired pedestrians».[32] When a pedestrian footpath is next to an unpaved area, an edge should be built with suitable materials to make it immediately visible and audible if a person walks with a stick. Changes in height should be connected using slight slopes or ramps signalled with chromatic variations. The intersections between pedestrian footpaths and carriageways have to be suitably signalled to the visually impaired.[33]

The two tables below give examples of different materials used for footpaths and children's playground areas as well as their advantages and disadvantages.

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[28] See chapters 14, 14, 16, 17 and 18 of Turner, S. (editor) (2007).

[29] Slips are caused by inadequate friction between the foot and the pavement. This can be due to the material and construction of the sole of the shoe, the nature of the pavement surface, the presence of lubricants such as water, any surface treatments such as sealers, and the maintenance of the surface. Polished hard surfaces can become slippery due to the presence of fine dust or grit as well as by water. According to Italian Law 236/1989, point 8.2.2 *Pavements*, slip resistant pavements are pavements built with materials with a friction coefficient, measured according to the method used by British Ceramic Research Association Ltd. (B.C.R.A.) Rep. CEC. 6-81, greater than:

- 0.40 per element slipping leather on a dry pavement;
- 0,40 per element slipping standard hard rubber on a wet pavement.

[30] According to Italian Law DM 236/1989, point 8.2.2 *Pavements*, the joints between the elements of a pavement must be less than 5 mm, be made with long-lasting materials, be flat and not have ridges of more than 2 mm. The grates in the pavement must have bars that do not let a 2 cm diameter ball pass through; grates with parallel bars have to be placed so that the bars are orthogonal to the direction in which people walk.

[31] Turner, S. (editor) (2007), p. 14-7.

[32] Turner, S. (editor) (2007), page 14-8.

[33] See Italian law DM 236/1989, point 4.2.1. Percorsi - Paths.

Table 2 Different materials used for pedestrian networks (Turner, 2007. page 14-8)

Surface	Advantages	Disadvantages	Design Issues
Concrete and asphalt	Require minimum ongoing maintenance. Any maintenance is inexpensive. Surface can easily be reinstated if removed. Provide longest service life.	Can be aesthetically displeasing. Asphalt can be confusing for pedestrians as it is associated with a 'road' surface. Asphalt can 'sink' and produce protrusions, especially at kerbs.	Texture with a broom finish (perpendicular to the direction of travel) to enhance friction and improve drainage. Concrete shall not be painted. Joints between units shall be less than 13 mm.
Stone pavers and unglazed brick	Highly decorative. Easy to replace if damaged. Easy to reset if displaced.	Small units can move independently and create a trip hazard. Can be difficult to maintain crossfalls. Can cause vibration to users. Some pavers or joints are susceptible to moss.	Consider stamped or stained concrete instead. Joints between units shall be less than 13 mm. Needs a firm base (preferably concrete). Ensure good installation and regular maintenance to prevent moss growth and minimise/reset displaced pavers.
Split-face stone, cobblestones	Highly decorative.	Not easily crossed by the mobility impaired or walking pedestrians wearing some fashion shoes. Prone to moss and weed growth.	Avoid use in the through route. Can be used to delineate places to walk, and within other areas of the footpath.
Loose surfacing, such as exposed aggregate, gravel and bark	Inexpensive to install. Can be aesthetically pleasing. Can fit well in 'rural' environments.	Can cause severe problems for the mobility impaired if not well compacted. Requires significant maintenance commitment. Very prone to weeds.	Avoid use in the through route unless there is an extremely high aesthetic justification (such as in a botanical park). Use to manage vegetation and street trees only (and take measures to prevent materials spilling into the through route)
Tactile paving	Provides a positive tactile way-finding cue for the vision impaired.	Can be aesthetically displeasing.	Should be used in a consistent way and only in specified locations.

Table 3 Paving materials for children's playground (a review of the table in Dessì, 2007)

MATERIAL	ADVANTAGES	DISADVANTAGES
Lawn	• Soft surface • Good for many kinds of games	• Unfit for use when raining
Soil	• Soft surface • Low cost	• With rain → mud • Without rain → dust
Gravel	• Good appearance • Low cost	• Stones can be thrown
Mixture of clay and sand	• Low cost	• Difficult to make the right mixture
Asphalt	• Suitable for many kinds of games (bicycle, skates, ...)	• If not used properly can be abrasive • Absorbs heat during the summer • Can become soft • Looks ugly (above all if widespread)
Concrete	• Minimum maintenance costs • Suitable for many kinds of games (bicycle, skates, ...)	• Not very elastic • High initial cost • Causes glare (above all if widespread)
Rubber tiles	• Excellent impact absorbing surface • Good protection against injuries caused by falls • Highly durable • No maintenance • Available in a wide range of colors and patterns • Slip resistant	• It can't be used to create an irregular or rounded playground area • High cost
Wood chips (shredded hardwood without the other scrap pieces of trees like bark or twigs)	• Organic loose materials • Low cost • High level of safety and cushioning	• Not accessible to those who use wheelchairs or crutches (except for engineered wood fiber EWF, which has proven to be cohesive enough to permit the use of wheelchairs and crutches and resilient enough to provide cushioning that protects children in case of falls) • Require maintenance and periodic replacement

The materials used for paving, buildings and equipment of pedestrian urban areas contribute to achieve comfort.

The ground is particularly important insofar as the air temperature of a place depends on the exchange of heat with the ground. Due to their luminous radiation, all materials used in an urban area play a role in the perceptive well-being.

Table 4 The albedo range for some of the walking environment materials (re-edit by the author from Dessì, 2007 and ITACA protocol[34])

MATERIALS	ALBEDO
Roads	
New asphalt	0,05
Used asphalt	0,20
Shiny grey marble	0,7
Shiny dark marble	0,35
Shiny grey granite	0,2
Shiny light-coloured limestone	0,65
Shiny dark limestone	0,5
Red bricks	0,26-0,3
Light-coloured brown bricks	0,45
Smooth concrete	0,35-0,46
Unpainted wood	0,41
Building walls	
Light-coloured external surfaces of buildings	0,60
Dark external surfaces of buildings	0,27
Surfaces in stone	0,20
Cement	0,22
Roofs of buildings	
Tiles	0,12
Slate	0,14
Undulated sheet metal	0,10
Urban and green areas	
Dry grass	0,20
Green grass	0,26
Dead leaves	0,30
Lakes	0,07
(dark) earth roads	0,04
Different kinds of terrain, clay	0,14
Woods	0,07
Woods in autumn, fields with ripe harvests, plants	0,26
Dry sand	0,25
Wet sand	0,15

The thermal properties of materials (such as specific heat and conductivity) and radiometric properties (such as albedo and emissions)[35] normally used in urban areas (concrete,

[34] ITACA, *Protocollo Itaca per la valutazione della qualità energetica ed ambientale di un edificio*, «Le Aree di Valutazione e le Schede», 15 gennaio 2004, Table 1, page 9.

[35] The radiometric properties of emissions and albedo are the values used to determine perceptive and visual comfort and the thermal comfort provided by materials. The former provides the reduction or increase value undergone by direct and diffused solar radiation (short wave radiation exchanges) when it hits coating materials. Instead the latter involves the reduction or increase undergone by the surface temperatures (infrared long wave radiation exchanges) of all urban materials (vegetation, water, pavement materials and vertical coatings).

asphalt), effectively induce a substantial change in the energy balance which in turn raises the urban temperature (Urban Heat Island – UHI).

The materials used in an urban environment also affect air quality due to the harmful emissions they can produce. Therefore it is important to:

- use materials of attested a-toxicity;
- use easy-to-maintain materials and components;
- protect from abrasion and wash-out the materials that can release substances which toxicity has not yet been sufficiently proved;
- avoid using materials that can facilitate the accumulation or formation of dust and vegetal or animal organisms;
- avoid using potentially toxic substances in the maintenance of green areas.

The materials and equipment in urban pedestrian areas also play a role in providing acoustic comfort. In fact, the reverberations of noise have an effect on being able to stand and talk. The roughness of the coatings helps to absorb and disperse high and medium frequency sounds. Outdoor asphalt pavements have a very reflective surface, locally intensifying sound. Instead, paved footpaths provide greater absorption due to the gaps between the slabs.[36]

4. Conclusions

In conclusion although this paper deals in priority with Accessibility, Safety and Comfort, to re-design an urban space it is imperative to follow and, then, to satisfy all the requirements (security, usability, appeal, sociability, management, integrability), because an urban space of quality is the one determined by people's needs. Indicators are useful tools to evaluate the quality of the existing urban situation, to guide the choice of the actions needed to make it suitable to pedestrians needs and expectations and finally to inform the planning and design of an urban structure at pedestrian size. To the "essential" indicators previously described, more should be added for taking into consideration other aspects that make comfortable and appealing the pedestrian environment; as already mentioned they are actually studied in the Department DIPSA of the University of Roma TRE and they still need to be further detailed.

A valid indicator to measure the quality of a public space is the development of relationships between people. To meet the citizens' consensus though it is very important to conceive projects with the cooperation of resident or usual users of the area to be re-designed. Although necessary activities can also be performed in an unattractive space, without minimum spatial standards and without comfort characteristics, it is clear that optional activities depend to a significant degree on what the place has to offer and how it makes people behave and feel. Squares, street closures and shared spaces are an opportunity to revive entire urban areas, sparking the development of new recreational and/or commercial activities and attracting new pedestrian flows. These spaces have to be a part of a seamless pedestrian network, supported by traffic calming measures which, for the maximum efficacy in reducing vehicular speed, should be implemented at the same time. Indeed, for obtaining the complete pedestrians' satisfaction, the measures that increase safety and accessibility have to be accompanied by others that improve the street legibility and that guarantee comfort and attractiveness.

[36] Cfr. Grosso (2005).

It would be very interesting for deepening the work, to link the devised indicators to the already existing measures. This would make possible a check on their consistency and usefulness. It could also point out some lacks that could be mended by devising new appropriate measures.

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Conclusions from the Functional Needs section.

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Introduction

Working Group 1 Functional Needs focussed on the collection of knowledge about the physical needs and performance of pedestrians. The work was based on the PQN conceptual framework. The working group aimed to cover the issue comprehensively and systematically. Although work in a COST Action is not funded centrally, the Working Group managed to produce 15 dedicated papers, totalling some 300 pages on the issue, roughly covering all walking decision levels and policy development and implementation stages. In total it delivers an impression of what the front runners in the field know about the issue.

Conclusions

First orientation on common practise
The first step in the project was to develop Country Reports on the state of affairs in the participating countries. COST offers grants for Early Stage Researchers to do a Short Term Scientific Mission (STSM). Within the context of such a STSM the content of the Country Reports was studied and related to results of earlier international research projects and reported on the findings in a voluminous report. Additionally the researcher evaluated a sample of European cities. It appeared that nearly all cities in the sample have implemented measures to improve public spaces, networks and sites. Good examples of site level interventions concerned improvements of crossings and public transport waiting areas. Network level intervention examples concerned link improvements and route improvements, like traffic calming. Examples of structure level measures included the quality of rest areas, meeting places and squares, as well as zone interventions (school zones, residential areas). It is however obvious that even the good examples do not score on all of the key quality factors (connectivity, conspicuity, comfort, convenience and conviviality) at the same time.

Availability of data
One of the benefits of a systems approach is that it produces insights enabling researchers to actively check for completeness and validity of data resources. The systems approach provides a framework for looking at the data from a wider perspective than commonly used. It was found that the availability and the quality of data on mobility and safety leave a lot to be desired. Pedestrians are disproportionally underrepresented in police crash statistics and in mobility surveys. The accuracy and completeness of these data are not always satisfactory. An important impediment to proper coverage of the pedestrian issue is that the definitions used for acquiring the data do not cover important aspects of walking and sojourning. This is a great obstacle to proper attention to the pedestrian issue.

Figuring out the magnitude of the issue

The magnitude of a safety problem for pedestrians cannot be convincingly shown without reference to the magnitude of the problems of other groups. For each application of the accident and injury data the correct exposure measure should be used to express the relative risk that pedestrians undergo. This is sometimes made impossible because the required data are not available, or has to be collected at great cost. For a valid comparison a measure must be used that has the same purport for all of the groups included in the equation. In most cases the only measure available, which to some degree qualifies, is the number of reported accidents or casualties per inhabitant. With regard to setting targets at the national level, the use of numbers of casualties is preferred above setting targets in terms of risk.

Image from combined data sources

Usually the safety of walking is assessed by using road accident data, as they are reported by the police. An important downside of this practise is that the definitions used for acquiring the data do not do justice to the safety of walking and sojourning. By combining multiple data sources, such as the police accident records, hospital records, medical emergency services records and sometimes insurance records, a much better image of the state of affairs can be produced. This induces very different conclusions. From road safety data it shows that the number one issue of pedestrian safety is crossing accidents. From combined safety data it appears that, depending on the winter situation of a country, while travelling, 3 to 9 times more pedestrians are injured by falls than by collisions with traffic. With the ageing of the population the share of injuries due to falls in pedestrians will increase substantially. Calculations regarding societal costs showed that about 15% of all travel accidents (including those by other modes) expenses are related to falls in pedestrians. The total damage per year resulting from pedestrian travel injuries amounts about 130 Euros per person per year (equals roughly 5% of an average employee’s income or 1.4 billion Euros per year in a country like The Netherlands).

Unlike motor vehicle injury accidents, most pedestrian injury accidents happen within urban areas. Fatality rates per 100,000 inhabitants vary from 3.8 per 100,000 in the safest countries (NL, SE) to higher than 14 per 100,000 inhabitants in others (PL, PT).

Issues from task performance

Although walking is the most natural and simplest way of getting around, it still is not task that everyone can perform without reasonable risk and trouble. In complex situations the risk of getting an accident increases, for everyone, but particularly for children, the elderly and people with mobility handicaps. Children can not be expected to be able to perform at the level that modern, complex traffic situations demand. Also, in some situations the task demands supersede the competences and abilities of the elderly and mobility handicapped, increasing the risk of an accident substantially. Simplification of tasks would help everyone, since this will make walking more comfortable and easy for very able persons as well. It appears that there are many options to simplify walking tasks at the strategic, tactical and operational levels. Walking should not be treated as an isolated mode of locomotion. It connects different transport modes. It is the key to inter-modality, and therefore crucial to all modes.

Determinants for strategic walking and sojourning choices

Strategic decisions regarding walking (whether to walk or not, where to walk to, when to walk) are influenced by a number of factors, such as individual abilities and competences, health, the distribution of places to go and distances towards them, built environment characteristics, barriers in public space, availability of certain transport modes (like public transport), availability of information systems and other essential services that are needed along the way, security, income, education level, social barriers.

ITS support for pedestrians
Intelligent Transportations Systems can simplify on-trip tasks while walking. It appeared that there are an number of application areas: for getting contact or localising, for navigation, for alerting or informing of dangers, for adapting the environment to pedestrian conditions, for promoting security and for supporting pedestrians with special needs.

Understanding route the pedestrian's route choices
Route choices are affected by a number of parameters. The most important one, of course, is distance. Other relevant quality factors are physical access: safety (safe crossing facilities, motor traffic volume and speeds), accessibility (width of sidewalks, steepness of slopes), attractiveness (maintenance of public space, lighting), and comfort (noise level, vegetation and shadow cast). Additionally there are 'soft factors' (social forces), trip purpose, personal fitness and moods. There are trade-offs between distance and quality.

Walking abilities and the identification of specific groups
Individual abilities and disabilities set the scene for operational walking, sojourning options and safety. In general there are four kinds of abilities relevant for walking: physical abilities, psycho-motor abilities, sensory abilities and cognitive abilities. Depending on the preconditions regarding the physical environment, social environment and transportation access, a number of special groups can be discerned: children, adults, elderly, people with handicap, and other groups, each having their own packages of needs regarding the system. For this some concrete guidelines can be given.

The safety of street crossing
It is generally acknowledged that the safety of streets crossing poses a major problem for pedestrians. Of the severe collisions with vehicles, more than half of the accidents concerned crossing. Children below the age of 11 and elderly above 75 year are the most vulnerable groups. In both cases abilities and functional constraints, are the dominant factor. The severity of the outcome of the accident strongly relates to the resilience of the walker. Particularly the elderly are relatively fragile. Crossing facilities need to be safe, comprehensible and convenient. Since crossing a road involves a complex task, it is important to reduce the cognitive load. Thus signalised crossings are generally safer than un-signalised ones. Feasibility and safety depend on the convenience of the crossing location, the volume and speed of traffic to cope with and conspicuity and visibility (from both the walker's and the driver's perspectives). Measures to reduce conflicts and conflict severity are: separation of road users by infrastructure design, improve conspicuity, speed limits and speed control, vehicle design, and driver and pedestrian education.

Public transport accessibility
Public transport can be seen as an extension of walking. Public transport attractiveness relates to high public transport speeds, high frequencies and high comfort. A primary factor regarding attractiveness is the type of stop/station and service offered there. The walking distance to the public transport stop comes second. Next walking comfort plays a role. The attractiveness can be calculated through a formula that is provided in a dedicated article in the report.

What can we do to improve walking and sojourning conditions?
One of the distinguishing features of a system approach is that it entails a multitude of strategies and policies combined to improve the pedestrian's situation. It seldom relies on one single category of measures, discipline or strategy to achieve improvements. It covers a wide range of actors. A first step is to improve preconditions for policy development and implementation: without insight and awareness of deficits of the system and problems for pedestrians, there is no chance of any improvement. There must be willingness to improve. The organisations must be able and have the means and tools to take action. Implementation must be organised, evaluated and monitored.

The Country reports, plus professional expertise, were used to take stock of options regarding strategies and policies to improve the pedestrian's situation. Main categories of policies and strategies discerned are: Land use and transportation policies for setting the stage for making it more possible and attractive to walk, Safety policies and strategies, Acquiring knowledge to improve the quality and effectiveness of policy development and measures, Stimulating planning and action, Encouraging and facilitating walking (campaigns) and Lobbying and providing incentives or structures for making it happen.

The design of the walking environment.

The mother of action for the improvement of walking and sojourning in public space is design of public spaces. Architecture has 'always' played a leading role and this still is the most successful field in promoting walking. Public space designers produce tangible and measurable effects. The most important indicators for walking and sojourning quality are the amount of space devoted to pedestrian mobility, the density of the pedestrian network, the amount of streets with traffic calming, the amount of parking areas and accessibility of public transport. Important measures concern: providing for pedestrian activities, at least based on minimal requirements for the amount of space needed; traffic calming with 'chokers' and pedestrian refuges; speed control at street crossings; street closures for sojourning activities; shielding against extreme environmental conditions (heat, wind, humidity, noise etc.); provision of seating and other useful street furniture; application of comfortable, attractive, safe and durable materials.

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