To what extent can ITS improve Pedestrian Mobility and Safety – Main Focus Children

Presented at the 25th ICTCT Workshop in Hasselt, Belgium
Road safety in a globalised and more sustainable world - current issues and future challenges
November 8th & 9th 2012

Per Gårder\textsuperscript{a*}, Hector Monterde-i-Bort\textsuperscript{b}, Charlotta Johansson\textsuperscript{c}, Lars Leden\textsuperscript{c,d}, Socrates Basbas\textsuperscript{e} and Anna Schirokoff\textsuperscript{d}

\textsuperscript{a} University of Maine, Orono, ME 04469-5711, USA
\textsuperscript{b} University of Valencia, E-46010 – VALENCIA, Spain
\textsuperscript{c} Luleå University of Technology, Division of Architecture and Infrastructure, SE-97187 Luleå, Sweden
\textsuperscript{d} VTT, P.O. Box 1000, FIN-02044 VTT, Finland
\textsuperscript{e} Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

Abstract — A sustainable urban environment may have a focus on how to provide food, clean water, clean air, and energy to a growing urban population. However, an undoubtedly important aspect of sustainability is how to provide for transportation of people and freight. A sustainable urban environment will need to rely less on private automobiles and more on walking, bicycling and public transportation. In addition, public transportation cannot take people from door to door, so public transportation trips include walking or bicycling components as well.

We will not move towards a more sustainable society unless we accept that children are people with transportation needs, and ‘bussing’ them around, or providing parental limousine services at all times, will not lead to sustainability. Rather, we will need to make our cities walkable for children, at least above a certain age. But today, many parents feel that their cities are not safe even for their 15 year old children. Safety has two main aspects, traffic safety and personal safety (risk of assault). Besides being safe, children will also need an urban environment with reasonable mobility, where they themselves can reach destinations with reasonable effort; else they will still need to be driven.

This paper analyses and compiles several ways that Intelligent Transportation Systems (ITS) can aid pedestrians, especially children. Different uses and possibilities for improving the mobility and safety of pedestrians in urban spaces are explored and classified into groups by function.

Apart from a comprehensive literature review, this paper presents results from expert questionnaires focusing on the potential safety and mobility benefits to child pedestrians of targeted types of ITS. Based on a first questionnaire, where 20 experts participated, fifteen areas of interest (problem areas) were defined. A second questionnaire was used to rank the problem areas by importance. Full responses were received from 23 European, North American and Israeli experts. This paper focuses on six of the problem areas and potential safety and mobility benefits of different ITS aids.

One aspect of the paper is how technology can be used to guide people away from dangerous streets and crossing points (traffic safety) and away from dangerous neighborhoods (personal safety). But the paper also discusses how we can use technology to make drivers notice that there are children nearby, and how to reduce vehicle speeds so that children and automobiles can share the same space. Other aspects covered are how technology can be used to take over where drivers fail, and to warn child pedestrians when someone runs a red light or commits another infraction.

* Corresponding author. Tel.: +12075812177; fax: +12075813888.
E-mail addresses: garder@maine.edu (P. Gårder), hector.monterde@uv.es (H. Monterde-i-Bort), charlotta.m.johansson@ltu.se (C Johansson), lars.leden@vtt.fi and lars.leden@ltu.se (L. Leden), transp@edessa.topo.auth.gr (S. Basbas), anna.schirokoff@vtt.fi (A. Schirokoff)

Keywords: Speed, safety, children, red-light-running, intelligent transportation systems
1. Introduction

Information technology (IT) is 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 what is called “Intelligent Transportation Systems” (ITS), which refers to the application of information and communication technologies to the transport infrastructure and vehicles. The aim is to improve the efficiency and safety of transportation. In the context of this paper, it is to meet pedestrian quality needs, and especially the five functional requests specified below to create a more sustainable world.

A sustainable urban environment may have a focus on how to provide food, clean water, clean air and energy to a growing urban population. However, an undoubtedly important aspect of sustainability is how to provide for transportation of people and freight. A sustainable urban environment will need to rely less on private automobiles and more on walking, bicycling and public transportation. In addition, public transportation cannot take people from door to door, so public transportation trips include walking or bicycling components as well.

An inadequate traffic planning regarding pedestrian needs can lead to an unfriendly “walking environment” with people feeling unsafe. This can go as far as creating a real fear of walking to an activity or a destination point, excluding some vulnerable road users from important activities in society. The reduction in walking has economic implications for society (e.g., costly vehicle-aimed infrastructure, negative environmental aspects of vehicle traffic) but even more so for us as individuals such as health loss due to less exercise. It is important to improve the walking environment to attract new pedestrians, e.g. children, but it is equally important to aid current pedestrians. The aim should be to improve safety, security, mobility and aesthetics while reducing traffic noise, emissions and severance (or barrier) effects to facilitate pedestrian trips. This will lead to a greater number of people who decide to leave their house for a walk, simply to enjoy it (Nicholson, 2008) with the confidence of feeling safe in the street.

We will not move towards a sustainable society unless we accept that children are people with transportation needs, and “bussing” them around, or providing parental limousine services at all times, will not lead to sustainability. Rather, we will need to make our cities walkable for children, at least those above a certain age. Today, many parents feel that their cities are not safe even for their 15-year-old ‘children.’ Safety has two main aspects, traffic safety and personal safety (risk of assault). Besides being safe, children will also need an urban environment with reasonable mobility, where they can reach destinations with reasonable effort; else, they will still need to be driven.

From a road safety viewpoint, pedestrians should be provided with safe, segregated paths where they do not have to interact with vehicles. However, that cannot always be achieved. A series of measures should be considered to improve pedestrian safety and mobility and change people’s daily habits and their movements (Elvik and Hoye, 2009). In this paper, accessibility issues are included in the mobility concept.

Apart from a comprehensive literature review, this paper presents further results from expert questionnaires focusing on the potential safety and mobility benefits to child pedestrians of targeted types of Intelligent Transportation Systems, ITS. The basis for this is two questionnaires distributed to experts. Fourteen European experts and six North American experts responded to Questionnaire I; Questionnaire II got full responses from 15 European experts, six North American experts and two Israeli experts.

The first expert questionnaire was structured to cover the following five functional requests, or needs, of child pedestrians:

1. Environmental adaptation (using ITS to change driver behavior to child pedestrian limitations)
2. Guidance (leading or navigating the pedestrians)
3. Danger alerts or information (about risks)
4. Confidence and security enhancements (to feel safe enough to leave home and walk)
5. Contact systems (to get in touch with others and/or being localized)

Based on the experts’ responses to the first questionnaire, fifteen areas of interest (problem areas) were defined. In the second questionnaire, the experts ranked these areas with respect to interest for developing ITS services. The nine areas deemed by the experts as the primary ones for developing ITS services are discussed in an article published in the TEC Magazine (Leden et al., 2012a) as well as in another paper.
presented at the 25th ICTCT Workshop in Hasselt, Belgium (Leden et al., 2012b). However, the remaining six areas are all important from a safety perspective and they are discussed in this paper. These six priority areas as presented in Questionnaire II, and listed from higher to lower priority, are:

- Child pedestrian not knowing that a fast-moving car is approaching an intersection
- Child pedestrian route taking them to dangerous street (high crash potential) or dangerous crossing point
- Child or other pedestrian violating red light (walking during don’t walk phase)
- Child or other pedestrian NOT knowing that a red-light-running car is approaching
- Child pedestrian route taking them through a dangerous neighborhood
- Emergency vehicle traveling at high speed

The priority area listed last—that an emergency vehicle is approaching at high speed—is a special case of the top one—that a child pedestrian does not know that a fast-moving car is approaching—so these two areas are discussed together in this paper. The second area—that a child pedestrian route takes them to a dangerous street, one with a high crash potential, or dangerous crossing point, and the fourth area—that a child pedestrian route takes them through a dangerous neighborhood—also have a lot in common with respect to solutions, how to guide children to safer surroundings, and these two areas are therefore also addressed together. For each problem area, examples of related ITS services are presented, based on the review of literature and opinions expressed by the experts. The most important developments are described with references to websites from which one can gather more information.

2. Results

ITS may be needed to satisfy quality needs of pedestrians and drivers. Signalized crosswalks can be made intelligent, so that they automatically detect pedestrians, and signal their presence to vehicles or their drivers, as well as prioritize pedestrian movements and adapt the length of the green phase to the number of pedestrians. Especially children and elderly pedestrians need such features. ITS in motor vehicles may be the most efficient measure to achieve a safe and independent freedom of movement for pedestrians. This includes controlling vehicle speeds whenever pedestrians are nearby; see e.g. Gårder (2004). However, if a pedestrian or bicyclist is hit by a large truck or bus, the fatality risk is high at any speed. Therefore, full auto brake may be a necessary function on heavy vehicles if they cannot be diverted away from urban areas.

Below follows a more general description of a select number of ITS systems that can be used for alerting or informing drivers of the presence of a pedestrian, or alert or inform pedestrians of potential risks along their route. We can distinguish between two kinds of systems dependent on whether the detector is mobile (attached to the vehicle or pedestrian) or fixed. The warning device can also be mobile or fixed to the roadway infrastructure.

An example of a system based in the synchronization of portable devices (using a Geographic Positioning System, GPS, in a car and a mobile phone for a pedestrian), is the Dedicated Short Range Communications system (DRSC) which advises the driver and the pedestrian when the proximity of the devices indicates danger of contact. There are also systems which advise the driver, by means of the GPS device installed in a car, of the presence of a pedestrian in a risk space. Other developments of this type have been based on the localization and intensity of activity in the cellular (mobile) phone network, measuring the intensity and place of the phone activity to estimate, by computer algorithms, the level of road user presence in streets, as the Italian LocHNESs project does (Calabrese et al., 2011).

Among systems using fixed devices (generally installations along pedestrian paths) the PICS project (Development of Pedestrian Information and Communication Systems) can be mentioned. It has been tested in Japan (Yachi, et al., 1999) and in Australia (Aotani et al., 2001). The system is composed of an infrared beacon transmitter and hand-held receivers (PDAs or mobile phones). The primary aim is to improve the safety of visually impaired and elderly pedestrians. The transmitter sends the name of the intersection, the direction to the intersection, the status of the pedestrian signal light, and other local information to a hand held device. Visually impaired people get the information via voice messages whereas elderly and other disabled people get information via literal, imagery and/or voice messages. The goal is to provide the pedestrians with the appropriate information for safe, easy, convenient and comfortable travel in a timely manner and consequently improve the quality of their daily lives. A 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) have devices detect the presence of pedestrians, and approaching drivers are alerted by special signals.

Besides the systems commented on above, technologies that can be used to detect and/or to alert road users include: microwave, ultrasonic and infrared detectors (to detect presence); count-down signals (to inform pedestrians about time remaining until red as well as until green); in-pavement lights (to alert drivers about the presence of pedestrian crosswalks); illuminated pushbuttons (immediate feedback to pedestrians about ordering reception); animated eyes display (to alert pedestrians to look towards approaching traffic); and signal-mounted speakers. Below follows a discussion of such systems with specific target functions and how experts rate their efficiency.

2.1 Child or other pedestrian not knowing that a fast-moving car is approaching

There are two strategies that can be applied to this problem. Either we accept that some drivers are going too fast and warn pedestrians that a fast moving car is approaching, or we slow down all vehicles so that no cars will be speeding, i.e. going faster than a desired speed. A clear majority of experts consider the latter solution to be preferable. Fourteen experts state that the applicable ITS solution would be Intelligent Speed Adaptation, ISA, to reduce approach speeds. Another six experts state that one should go one step further and stop the vehicle when necessary by using Full Auto Brake when a pedestrian is detected in or near the path of the vehicle.

If the strategy is to slow down all vehicles to a safe speed, can that be done to ambulances, fire trucks and police cars during emergencies as well, or should one rely on audible and visible warning systems to keep pedestrians from getting in conflicts with emergency vehicles? Three experts suggested that approach speed control, or ISA, should be used whereas two suggested that Full Auto Brake should be used when a pedestrian is detected in or near the path of the emergency vehicle. In the United States, there were—according to the National Highway Traffic Safety Administration’s database FARS—seven fatal pedestrian accidents in 2011 involving emergency vehicles in emergencies, so such vehicles are involved in fewer than 2% of all fatal pedestrian crashes. Also, only two of the pedestrian fatalities with emergency vehicles were deemed to be caused by speeding vehicles as opposed to 348 not involving emergency vehicles. But that emergency-vehicle accidents are not classified as related to speeding may be solely because police officers consider high speed for such vehicles to be legal and acceptable, so they do not check off speeding in the crash report even if the vehicle was traveling well over the speed limit.

A total of ten expert suggestions support warning the pedestrian of fast moving cars in general. Six experts suggest we use an audible warning telling them that a car is approaching at high speed; four experts suggest that we warn pedestrians using a street display. It is not surprising that audible warnings are recommended more frequently than visual ones. Unpublished research by the authors has shown that people react the quickest to touch (tactile message), second quickest to what they hear (audible message) and the slowest to what they see (visual message). And it is fairly obvious. Think about being at a busy location such as in an airport terminal, and someone touches your shoulder, someone calls out your name, or someone holds up a sign with your name. What would you be most likely to react to quickly? That people react quicker to acoustic information than visual has been validated by Kaufmann et al (2008). That audible messages are more effective than visual ones is probably true especially for children. No expert suggested that pedestrians be warned on a device they carry with them. This may be because such systems are still very uncommon. However, such devices could be vibrating and give a tactile message as well as an audible one.

With respect to emergency vehicles, besides relying on current vehicle-mounted warning systems, five experts suggest that pedestrians are warned on a street display when speed is high, and five experts suggest that pedestrians get an audible warning that a car is approaching at high speed. One expert suggests this warning be given every time an emergency vehicle is approaching, no matter if its speed is high or not. Finally, one expert suggests that the warning should be given on a device carried by the child.

Besides slowing down vehicles or warning pedestrians of fast-moving cars, we can try to voluntarily have drivers slow down to safer speeds, or at least to be more alert of potential pedestrians crossing. Two experts suggest that we use In-Pavement-Marker systems (IPM), also known as embedded pavement lighting, to achieve this. When emergency vehicles are approaching at high speeds, four experts suggest using IPM.
2.2 Child or other pedestrian violating a red light (walking during the don’t walk phase)

Eight experts suggest that vehicles be equipped with ISA, which slows vehicles down when they encounter jaywalking pedestrians. ISA can set a car speed to the characteristics of the specific pedestrian present. Seven experts want to go one step further and have the vehicle come to a full stop through emergency braking, i.e., Full Auto Brake, when a pedestrian is detected in or near the predicted path of the vehicle. In other words, a total of fifteen experts state that the vehicle—i.e. a computer co-driver of the vehicle—should take automatic evasive action and another five recommend that technology to be developed should “give an alert message to all approaching vehicles” when there is a jaywalking pedestrian in their path. This can be compared to seven experts suggesting that the pedestrian be alerted (audibly) so that the pedestrian can take evasive action when a vehicle is approaching while they cross during the red phase. Hopefully, introducing such systems would not increase jaywalking further. Other solutions aiming at affecting driver behavior is Collision Avoidance Systems (CAS) which aim at foreseeing and avoiding a collision, including those with jaywalking pedestrians. A special case of ITS solutions would be those which act on autonomous vehicles, those ‘driven’ without a driver.

2.3 Child or other pedestrian NOT knowing that a red-light-running car is approaching

Fourteen experts suggest that we reduce the frequency of red-light running vehicles by using camera enforcement. Ten experts suggest that we use “Full Auto Brake” and stop vehicles when drivers do not stop themselves for a red light, similar to Automatic Train Control Systems on mainline railroads. Eight experts suggest that we use red-light running detectors setting of an alarm (audible signal) on the street. Finally, one single expert suggests that we use red-light running detectors setting of a warning on a device carried by the [child] pedestrian.

2.4 Environmental adaptation of crossing points

Reducing red-light running and red walking or the consequences of those behaviors are not the only paths to improving safety at signalized intersections. There are several ITS solutions for adapting the environment to pedestrian conditions. Solutions and devices which are located along the street, near crosswalks, pedestrian paths, etc., and have as main objective to modify the environment by adapting it to the presence and characteristics of the movement of pedestrians, are discussed below. This includes lengthening of the walk phase, changing traffic signal phasing sequencing and forcing reduced speed.

Many of these functions require that a device be installed to detect the presence and the characteristics of the movement of pedestrians and cars using technologies such as ultrasonic sensors, Doppler radar, video imaging, or piezometric pressure sensors. Such detectors are referred to as “passive pedestrian detection.”

Detection can be combined with alerts directed to the driver, the pedestrian, or to the infrastructure, to adapt it to the particular characteristics of a specific pedestrian.

Systems making pedestrian signals more accessible include methods to provide “walk/don’t walk” information to pedestrian (Hughes, R. et al., 2001) using one or any combination of the following methods: monotone sound, speech message, vibrating surface and/or message to receiver hardware which is pedestrian-signal-mounted, pushbutton-integrated, or pedestrian-based.

Solutions directed to act on infrastructure can be exemplified by two classic British crosswalk systems, PUFFIN (Pedestrian User Friendly Intelligent Signals) (Davies, 1992) and PUSSYCAT (Pedestrian Urban Safety System and Comfort at Traffic Signals) (Beckwith and Hunter-Zaworski, 1998; Tan and Zegeer, 1995), as well as the DRIVE II project VRU-TOO (Vulnerable Road User Traffic Observation and Optimization) system (Carsten, 1998). Such systems replace the normal push-buttons and provide early activation of the pedestrian phase, an extension of the pedestrian phase for late arrivals, and provide privilege time, i.e., the walk phase is initiated even well into parallel vehicles having started their green phase, as well as longer pedestrian intervals when there are larger number of detections or the pedestrian velocity is lower than normal, such as for older adults or impaired people.

Examples of traditional types of ‘ITS’ with information to pedestrians and/or drivers are presented in Figures 1 and 2 (with photographs taken from www.flickr.com). In Figure 1, the pedestrian is presented with information on whether it is ‘safe’ to start crossing or not, accompanied by a countdown display showing time until the start of the green walk phase (on left), and remaining walk time in seconds (in middle and on right). To show remaining walk time is common in many countries and mandated in the US for most new signals (together with flashing red, rather than green as used in Europe). Time until the walk phase starts is
used in fewer countries, such as China, the Netherlands and Estonia, and only sometimes in those countries. The sign in Figure 2 is equipped with a detector that registers the presence of a pedestrian and gives a flashing message to approaching pedestrians telling them to look right (or left) before they step into the roadway. It can also be connected to lights that start flashing when a pedestrian is crossing, telling drivers that a pedestrian is in the crosswalk, or will be there soon.

In other cases, the ITS service is produced unknowingly to the user, e.g., optimizing an intersection’s signal timing, or setting minimum and maximum green times (Zhang and Wang, 2011).

A more futuristic example of ITS aid is presented in Figures 3 and 4 (Espinoza, 2008). They show different aspects of the Virtual Wall idea designed by Lee Han Young to ‘protect’ pedestrians in crosswalks (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” according to the ‘advertising’ (HanYoung, 2008).

There has been research and development of systems that can provide various types of information to pedestrians. Among the features of such systems are voice interfaces with input data by a voice recognition method and information output by a voice synthesis method. One of these systems can handle not only Japanese, but other languages such as English and Spanish (Ozaki et al., 2011).

Inventories of pedestrian ITS solutions and their applications with links to manufacturers are presented in the PedSmart project with a website (www.walkinginfo.org/pedsmart) developed by the University of North Carolina Highway Safety Research Center for the U.S. Federal Highway Administration. Main research lines are “Automatic pedestrian detection at Intersections”, “Variable (or Changeable or Dynamic) Message Signs (VMS/CMS/DMS),” and methods for identifying human figures in target settings (pedestrian detection) under different and variable conditions (sunny/shadowy, day/night, etc.) (Oliveira et al., 2010; Gidel et al., 2010; Lim et al., 2010).

2.5 Pedestrian route taking them to a dangerous crossing point or dangerous neighborhood

In most communities, there is a higher risk of being injured in a traffic accident than from an assault. If we look at the most serious outcome—death—more or less all countries in the world have more traffic fatalities than murder victims (assuming we exclude suicides), and more people injured in traffic accidents than from assaults, rapes and muggings. Furthermore, exposure to assaults is typically less random than the chances of
getting into a traffic accident. However, in some cities, the risk of becoming a victim of crime is greater than the risk of dying in a traffic accident. For example, New Orleans, Louisiana, USA, had 174 murder victims in 2009 whereas they in the same year had ‘only’ 42 people (motorists, pedestrians and bicyclists combined) killed in traffic accidents (as reported by the Federal Bureau of Investigation and the National Highway Traffic Safety Administration). And children are not exempt from getting murdered. In 2011, almost 14% of those murdered were preteens or teenagers, and a majority of the murders happened outdoors, many on public streets (McLaughlin, 2012). In other words, avoiding dangerous neighborhoods may be a high priority to pedestrians of all ages in New Orleans and in many other cities around the world.

Microsoft was granted a patent in January 2012 for its “avoid ghetto” feature for GPS devices. This system has a focus on pedestrians avoiding an “unsafe neighborhood or being in an open area that is subject to harsh temperatures.” Eight experts think such a system is a good idea, stating that they support pedestrian route production (walking directions) system to avoid areas that are undesirable. Seven experts suggest that child pedestrians carry GPS, such as a mobile phone with GPS, and that a parent is monitoring their location online, whereas three experts support the idea that child pedestrians be physically accompanied by a parent or other adult with a mobile phone who can call for help. Three experts suggest that streets have video cameras that are monitored by police and three experts suggest that streets have video cameras that automatically process images of people and events.

However, dangerous traffic is the bigger threat to children’s safety in most cities. Seven experts suggest that pedestrians are given route directions, on a GPS or cell phone, to have them walk around crossing points that are dangerous with respect to vehicle traffic. But there are alternatives to avoiding dangerous locations. The crossing points can also be made less dangerous with the use of technology, such as that covered in the previous section. Six experts suggest that streets have video cameras that process images of objects and people in a street, and, if a child is detected, an in-vehicle alarm is triggered in vehicles nearby. Five experts suggest that children carry emitting devices with signals picked up by a detector in the vehicle and that an alarm is triggered. This can either be done whenever a child is within X meters from the vehicle, where X can vary with vehicle speed (3 experts) or dangerous proximity can be determined by a GPS device when a child is already in the roadway (2 experts). Finally, a different strategy than avoiding dangerous crossing points, or mitigating their danger, is to change the child’s destination. This can obviously not always be done, but rather than trying to find the safest way to the closest convenience store or bus stop, maybe there is another one slightly further away that can be reached in a safer way, and quicker than the nearby one when following safe routes.

There are many ITS solutions that can be used for guidance (leading or navigating) away from dangerous points. For navigation, we can distinguish between two groups of devices: those based on GPS and others, the latter are normally used to complement the first in order to improve their accuracy getting a seamless positioning.

Among the GPS-based systems is “Easy Walk”, developed by Vodafone, which offers blind or visually impaired people information about their actual position (localization), and also permits them access to assistance and useful information so that they can move in an independent way. The use of this technology can also extend to non-handicapped people. The “Telmap Navigator” combines GPS and mobile phone technology to guide a pedestrian to the best possible route, using detailed maps with zoom and pedestrian footpaths, to public and private businesses. Once in a desired zone, one can easily find businesses on the map, and details like address and phone numbers. Nokia may have pioneered personal navigation using mobile phones, by including in some phone models three basic functions: navigation, position and travel distance; with options specially for walking. “Mobile Navigator 7” incorporates specific needs for pedestrians including a compass, which indicates the direction to your destination and remaining distance, exact to the meter. In addition, the software will actively prioritize the use of small alleyways, narrow paths and pedestrian-only routes. “Tele-Atlas” specializes in developing maps for GPS devices, and has developed versions of maps specific for pedestrians, combining its traditional Multinet cartographic database with a series of special attributes such as detailed information about tunnels, foot-bridges and pedestrian paths to provide security and comfort to people walking, and facilitating finding the shortest safe path to a person’s destination. “Google Maps” is probably the most used map system with route directions in the world. On July 15, 2008, walking directions were added (and bicycling directions are gradually introduced to more and more countries since 2010) (Wikipedia accessed June 18, 2012). If carried on a mobile phone, the current location is shown and directions are updated continuously if deviating from the originally recommended route.
Within the second group (non-GPS based systems), we can distinguish between two sub-types, systems based on the use of radio-beacons, and systems based on algorithms which estimate the movement of a person from data supplied by their own movements. Among the systems based on the use of radio beacons for guiding pedestrians are those that use Radio Frequency Identification (RFID) tags or transponders. A RFID tag is an electronic circuit that can be installed at a place, product, animal or person for the purpose of identification and tracking (using radio waves). Pedestrians can use it for navigation purposes, to guide someone from one point to another, to develop safe or time-optimal paths in cities, to help visually-impaired people, or to pay for bus tickets without actively making a transaction. A newer evolution in this field consists of the introduction of the Bluetooth communication technology in development of radio beacons. The “Talking Points” project, developed at the University of Michigan (2008), combines Internet, Bluetooth and a portable communication device such as a mobile phone. 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 the visually impaired but are also practical for the sighted community. The project is based on radio beacons (Bluetooth-beacons) at urban points of interest, such as public toilettes, bus stops, restaurants with menu in Braille. The beacons emit Web content—and the user can interact with this using their mobile phone—as well as tactile or audio information. The possibility of interaction by means of vocal commands is a new part of this.

A main difference between beacon-based and satellite-based systems is that the radio beacons do not need digital mapping, since they provide the information and their position by themselves. The radio beacons are also useful to complement satellite position systems in places with reception difficulty such as in tunnels and indoor spaces.

The second sub-type of systems, which are based on estimation algorithms of movement of a pedestrian from the data produced by his/her own movement, one normally beginning with a first position acquired from another system, such as GPS or RFID. The “MEMS Based Pedestrian Navigation System” is such an example. MEMS stands for ‘micro-electrical mechanical system’ and has a pedestrian navigation system which aims at seamless positioning based on 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 movements and positioning using a neural network (Cho and Park, 2006).

There are also ITS devices aiming at promoting confidence and/or security for a pedestrian to avoid becoming a victim. Devices such as cameras and emergency-call push-buttons/phones in streets, parks, stations, metro/train cars, elevators/lifts, etc., where the presence of pedestrians is expected, are typically devoted to this purpose. Personal security for pedestrians should be an obvious right. The fear to be assaulted—victimization—is one of the limiting factors for leaving home and walking, as revealed by the results of the SIZE research (Zakowska and Monterde-i-Bort, 2003; Monterde-i-Bort and Moreno-Ribas, 2003).

A special case of ITS in this field would be those resources developed to automatically recognize the behavior of pedestrians to determine which situations are likely to lead to more serious incidents, such as accidents, assaults and other suspicious activities (Candamo et al., 2010).

3. Conclusions
The consequences of inadequate traffic planning regarding pedestrian needs, including the specific needs of children, lead to an unfriendly “walking environment” where people often feel unsafe when walking, or parents do not dare to let their children travel unaccompanied by foot. It may exclude other vulnerable road users, besides children, from important activities in society. In order to improve the situation, helping current pedestrians and attracting new ones, especially children, the walking environment has to be improved. The question asked here is to what extent ITS can be used to do that.

Several ITS systems for improving pedestrian quality have been discussed. But it will be up to national, regional and local governments, through their ministries and agencies and public works departments, to promote, fund, and possibly mandate such systems. It is clear that we need to offer an acceptable level of convenience, efficiency, comfort, safety and security to pedestrians but it is less clear if society will prioritize resources towards this.

Finally, and maybe the most important aspect from the point of view of this paper, it is necessary to promote and offer support for research in the field of ITS applied specifically to child pedestrians and to find new applications for current ones. The goal must be to improve the mobility and safety of all road users, not
least children. The final target is a walking environment, partially relying on ITS, safe enough for children to travel independently to most destinations in a safe and secure manner. As a corollary to the classification of the possible fields of ITS benefiting pedestrians, we want to remind the reader that many of the systems discussed here contribute to helping solve more than one specific problem, giving increased options for mobility, confidence and safety. Hopefully, this will lead to a greater number of people who decide to leave their house for a walk, simply to enjoy it with the confidence of feeling safe in the street.

Acknowledgment

Much of the work presented here was developed within the framework of the PQN (Pedestrian Quality Needs) project (2006-2010) under auspices of the European Science Foundation (ESF), COST Action 358, EU RTD Framework Programme (Methorst et al., 2010).

We want to thank the following experts for answering the questionnaires; from Europe: Maria Alonso, Anna Anund, Karin Ausserer, Socrates Basbas, Eleni Chalkia, Wolfgang Fastenmeier, Padin Garrido, Jürgen Gerlach, Herbert Gstalter, Christer Hydén, Risto Kulmala, Jörgen Larsson, Dick Mans, Rob Methorst, Hector Monterde-i-Bort, Nicole Muhrad, Jürgen Pripfl, Ioanna Spyropoulou, and Thérèse Steenberghen; from Israel: David Shinar, David Zaidel; and from the US: Richard Blomberg, George Branyan, Leversen Boodel, Marcus Brewer, Dominique Lord, John LaPlante, Gabe Rousseau, Cara Seiderman, Ruth Steiner, and comments from Richard Knoblauch, Michael Ronkin, and Laura Sandt.

References


