Improving safety and mobility of Vulnerable Road Users through ITS applications

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Abstract

ITS Applications have in recent years assisted in reducing the number of fatalities in Europe. However, Vulnerable Road Users (VRUs) have not benefited as much as vehicle users. The EU-sponsored VRUITS project assesses the safety and mobility impacts of ITS applications for VRUs, assesses the impacts of current and upcoming ITS applications on the safety and mobility of VRUs, identifies how the usability and efficiency of ITS applications can be improved, and recommends which actions have to be taken at a policy level to improve ITS safety and mobility. This paper describes the results of the first phase of the project, in which the critical scenarios for VRUs are identified starting from accident data analysis, and following a user needs based on focus groups and expert interviews. From this basis, the most promising ITS applications for VRUs are selected according to their potential to address the specific needs of VRUs.

Keywords: Vulnerable Road Users, safety, mobility, Intelligent Transport Systems

Résumé

Pendant les dernières années des applications de transport intelligentes (ITS) ont contribués à réduire le nombre de décès en Europe. Toutefois, les Usagers Vulnérables de la Route (VRU) n’en ont pas bénéficiés autant que les utilisateurs de véhicules. Le projet VRUITS, qui est financé par l’UE, évalue la sécurité et l’impact de la mobilité des applications ITS pour les VRU et l’impact des applications existantes et futures sur la sécurité et la mobilité des VRU. Le projet VRUITS détermine comment l’utilisabilité et l’efficacité des applications peuvent être améliorées, et il recommande les actions nécessaires au niveau politique pour améliorer la sécurité et la mobilité. Ce document décrit les résultats de la première phase du projet, dont les scénarios plus remarquables pour VRU sont identifiés à partir de l’analyse des accidents et de la recherche des besoins des usagers de la route avec l’aide de groupes de discussion et des sondages d’experts. A partir de ces analyses, les applications les plus prometteuses sont sélectionnées en fonction de leur potentiel à répondre aux besoins spécifiques des VRU.

Mots-clé: Usagers vulnérables de la route, sécurité, mobilité, systèmes de transport intelligents

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Nomenclature

ADAS  Advanced Driver Assistance System
ARAS  Advanced Rider Assistance System
ITS   Intelligent Transport System
PTW   Powered Two Wheeler
VRU   Vulnerable Road User

1. Introduction

In recent years both technological developments and research activities in the fields of Intelligent Transport Systems (ITS) have primarily focussed on motorised transport to improve on safety and ecological standards by advancing equipment of vehicles and infrastructure. The uptake of ITS applications has assisted in the decrease of road traffic fatalities, particularly amongst passenger car occupants. However, Vulnerable Road Users (VRUs), such as pedestrians, cyclists, motorcyclists and moped riders have not enjoyed the same decrease in fatalities. Together, they account for 68% of the fatalities in urban areas (CARE, 2009). Motorcyclists account for 16% of fatalities, which is much higher than their contribution to traffic (CARE 2009). While some projects have considered VRUs from a safety viewpoint, they often aimed at avoiding or mitigating accidents with VRUs by equipping the vehicle and infrastructure. In the vehicle – infrastructure – human approach of ITS research, VRUs and their needs are not an active part of the “human” element in the ITS approach.

What is needed? The VRU must become an active, integrated element in the ITS, addressing safety, mobility and travel comfort needs of VRUs. The VRUITS project, which is sponsored by the European Commission and started on 1.4.2013, aims at actively integrating the “human” element in the ITS approach by focussing on needs of all relevant stakeholder groups into the development and adaptation process of innovative ITS solutions aimed at improving traffic safety as well as the general mobility of vulnerable road users. The VRUITS project places the VRU road user in the centre, assesses the impact of current and upcoming ITS applications on the safety and mobility of VRUs, identifies how the usability and efficiency of ITS applications can be improved, and recommends which actions have to be taken at a policy level to improve ITS safety and mobility. By applying a multi-disciplinary approach the VRUITS project aims at developing tools to evaluate, field-test and subsequently improve ITS for vulnerable road users.

The first objective of the VRUITS project is to assess societal impacts of selected ITS applications, and to provide recommendations for policy and industry regarding ITS in order to improve the safety and mobility of VRUs. Both ex-ante and ex-post assessment of the applications is performed in order to come to a consolidated set of recommendations.

The second objective is to provide evidence-based recommended practices on how VRUs can be integrated in Intelligent Transport Systems and on how HMI designs can be adapted to meet the needs of VRUs, and test these recommendations in field trials. Starting from usability study of current ITS applications, guidelines will be provided on the improvement of the HMI for specific user groups, such as elderly drivers. A key concept is also the integration of VRUs in cooperative traffic systems, either through one-way (tags) or two-way communication. The performance and usability of different concepts for the communication between road users in safety critical situations will be assessed. Field trials for a select number of applications will take place in the Netherlands (Helmond), with an emphasis on cyclists and PTW riders, and Spain (Valladolid), with an emphasis on pedestrians.

2. Methodology

Based on a comprehensive identification of situations for VRUs that are critical in view of traffic safety, making use of accident data, hospital data and in-depth studies, a taxonomy of the major critical scenarios for vulnerable road users is derived providing essential input to the development of ITS aimed at VRU safety.

In addition, based on an exploratory research approach applying focus group discussions, expert interviews and a literature review, opinions and needs of all relevant stakeholder groups are integrated into the discussion of VRU and traffic safety. Not only representatives of identified vulnerable road user groups but also of national and
European authorities, of infrastructure service providers and ITS related economy are focus of this approach resulting in a comprehensive catalogue of requirements that need to be considered in the development and application of ITS systems aiming at vulnerable road users.

Based on these findings ITS applications which affect VRU safety and mobility are identified, combining results regarding critical situations for vulnerable road users in traffic and the benefits as well as potential issues and hazards of these systems. As a result an inventory, categorizing and prioritizing existing and upcoming ITS services targeted at VRUs, also regarding positive or potentially negative impacts on safety and mobility, allows researchers and stakeholders to close existing gaps for new ITS and provides insight into the potential of existing technologies in this field.

The impact of selected services on safety, mobility and comfort is assessed based on accident data, literature and expert analysis. For the safety assessment, the methodology which has been developed for in-vehicle safety systems by Kulmala et al. (2010) is adapted towards VRU applications. The methodology covers the three dimensions of road safety – exposure, crash risk and consequence. It not only considers the intended effects, that is, the safety factors that the ITS is designed to influence, but also the unintended effects, e.g. the effect of behavioral adaptation (Kulmala, 2010), in a comprehensive, systematic and transparent way. In the analyses, the three main factors of traffic safety were covered by nine behavioral mechanisms as first described by Draskóczy et al. (1998). The method for quantifying the safety effects explicitly takes into account the general accident data available from e.g. the CARE database. The accident data is further subdivided according to different background variables, such as vehicle type, collision type, road type, weather and lighting conditions and location. The inputs for the safety estimates were: expert estimates of effects by mechanism, the total number of accidents / fatalities or injuries from accident data and the share of accidents in each variable category. Some estimates were based on evidence from the literature, others on expert opinion due to lack of data or incomplete data (Kulmala, 2010). For improving validity and reliability of expert opinion on safety and comfort/mobility impacts expert judgment models are used, which use the opinion of different experts, as developed by Leden et al. (2000): The quantification forms input to a socio-economic impact assessment, taking into account accident trends for target years (2020 and 2030), road exposure trends and estimates on the fleet penetration of the application.

In parallel with the impact assessment, the usability of existing ITS applications for VRUs is assessed. An architecture is developed for the integration of VRUs in the traffic systems of the future, and methods for communication of safety critical information are assessed. The areas for improvement of the HMI for different VRU groups, such as elderly drivers and motorcyclists are identified.

Innovative ITS applications are tested at two test sites, in Valladolid (Spain) and in Helmond (Netherlands). The major aim of the trials is to benchmark the recommended practices regarding usability and integration of VRUs in cooperative traffic systems. Based on the evaluation results, an ex-post impact assessment is made of the applications tested in the trials.

The result of the work in the different areas is combined into a consolidated set of outputs, consisting of recommendations for industry to improve the efficiency and performance of ITS applications, and of policy recommendations.

3. Accident Data Analysis and Identification of Critical Scenarios

Analysis of a range of databases has been conducted to identify a number of scenarios for VRU’s. The CARE database has been used as the most representative database for EU accidents and data from national databases from Austria, Finland, Spain, Sweden and the UK have been compared to the CARE data for consistency of results. The main findings from the database are summarised in the following sections.

3.1. Pedestrians

- In all databases including the CARE database, it was found that accidents were most likely to occur when the pedestrian was crossing the road remote from a junction (Fig. 1).
The accident analyses suggest that in most if not all cases, the environmental conditions are not intuitively detrimental to road-crossing. That is, in the majority of the databases, the accidents tended to occur in fine weather and the road conditions were found to be dry. Also, there was some consistency suggesting that pedestrian accidents tend to occur between 12pm and 6pm.

It was found that in the majority of cases, the accidents tended to occur in urban areas on roads with lower speed limits (50km/h).

There was variation in some of the parameters – males are slightly over-represented in the CARE database whereas females are over-represented in some of the individual Member State databases – also there was no consistency regarding the accident month.

In the majority of databases including CARE, a passenger car was the most frequent collision partner.

Some important parameters could not be determined. These include vehicle characteristics, vehicle speed pre-collision and pedestrian actions prior to collision.

3.2. Cyclists

The majority of cycling accidents in the accident analysis were found to occur at junctions/intersections. One of the most common scenarios involved vehicles pulling out into the path of the on-coming cyclist at an intersection (Fig. 2a).

CARE data suggests that the most common scenario involves both the cyclist and the vehicle heading in the same direction but the vehicle then turns into the cyclist’s path (Fig. 2b).

Overall, males are over-represented in the data.

The majority of the accidents occur in fine dry weather during daylight hours.

The majority occur in urban areas on roads with relatively low speed limits.

3.3. Powered Two Wheelers

The most common scenario in the CARE accident analysis was found to be the PTW being hit by a vehicle (mainly passenger car) initially heading in the same direction and then turning across the path of the PTW (Fig. 3a).

This was not consistent with the national database analyses which suggest that the most common scenario involves vehicles pulling out from intersections into the path of the PTW. (Fig. 3b).

Males were far more likely to be involved in PTW accidents compared to females.

Most accidents occurred within urban environments.

It is thought that the majority occurred on roads with low speed limits (50km/h).

The majority of accidents occurred in fine and dry weather conditions during daylight hours.

The majority occurred during the ‘summer months’ (May to September).
4. User Needs Analysis

Based on focus groups with 143 participants from 5 different ITS user groups (adults, parents, adolescents, older road users and powered two-wheelers) in four partner countries (Spain, Finland, Austria, the Netherlands) and expert interviews with 10 international experts from the fields of ITS technology, policy and VRU representation the following aspects have been comprehensively assessed:

- Identification of critical situations for VRUs
- Assessment of needs of different user groups for ITS services & applications.
- Identification and prioritisation of ITS potential and technology prospects in view of VRU safety and mobility

Critical situations for VRUs proved to be usually related to high (car) speeds, high complexity and density of traffic, local weather conditions and maintenance of infrastructure.

System knowledge among focus group participants was on a high level with a high share of standard in-vehicle (car) systems, with known infrastructure based ITS mainly regarding traffic lights and traffic signs. Smartphone-based applications for routing and navigation are already known and regularly used by all involved road user groups for pre-trip and on-trip information. Participants in all countries showed to have experiences on all levels of ITS (mobile applications, in-vehicle, infrastructure) and technologies (informing, intervening, warning) with a high level of experiences especially among car drivers (Blind Spot Detection, Intelligent Speed Adaptation, GPS, Cruise Control, etc.).

Main identified benefits and advantages of ITS for VRUs are increased visibility of VRUs (communication, warning, intervention); increased overall traffic flow (automation); economic (less fuel consumption) and ecological (less CO2 emissions) aspects; increased comfort in traffic (information).

On the other hand potential adverse effects are a perceived loss of autonomy, distraction (sounds, visuals, interaction with HMI), and potential for overreliance/overconfidence, technical limitations and reliability.

The overall willingness to use ITS for VRUs and the assessment of benefits for traffic safety and general mobility was assessed on a very high level by both, experts and focus group participants.

Future technological advancements are mainly expected in view of connecting road user groups (communication between VRUs and vehicles); increasing visibility and vision; standardisation of technologies; infrastructural developments and adaptation of legal requirements for broad scale deployment of technologies.

5. ITS applications for the critical scenarios and user needs

An inventory of ITS applications targeted to VRUs has been made with a total of 14 systems addressing pedestrians, 34 addressing cyclists, 28 for PTWs, and a number of 10 in-vehicle systems which benefit all kind of VRUs. In order to identify the most promising solutions, a workshop with 40 relevant stakeholders was held in Brussels on 18.9.2013. In this workshop, representatives of VRU groups, national and European authorities, infrastructure service providers and ITS related economy contributed their input to the prioritization process. The participants were divided over three different groups (pedestrians, cyclists, or PTW’s) according to their
expertise/interests, and ITS solutions for two scenarios, which were identified in the accident analysis and user needs as the most important for the specific group, were discussed. More specifically the scenarios were:

- **Pedestrians:**
  - pedestrian crossing the road, occluded or not from a parked car (Fig. 1);
  - support pedestrians at intersections to increase comfort and remove obstacles/barriers.
- **Cyclists**
  - vehicle on a crossroad, pedal cyclist crossing the road from the right or from the left (Fig. 2);
  - making cycling from location A to location B easier.
- **PTWs**
  - urban junction accidents with cars (Fig. 3);
  - urban single motorcycle accidents on straight roads.

After the discussions, participants were asked to select the three applications which have the most potential for VRU safety and rate these ITS solutions in a questionnaire, according to the following criteria: safety, mobility, technical maturity, deployment potential, acceptance (by VRU, drivers and government authorities), relevance for older people, relevance for people with disabilities, feasibility for children, usability of system interface. A five-point Likert scale was used for each of them. In addition, they were asked about potential negative side effects of the systems selected.

6. Results

Starting from the group discussions and the questionnaires, the following set of systems were considered by the workshop participants as the most interesting to be considered for further assessment in the VRUITS project (Table 1).

<table>
<thead>
<tr>
<th>ITS application</th>
<th>number of experts</th>
<th>Average score</th>
<th>Total score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blind Spot Detection</td>
<td>8</td>
<td>3.90</td>
<td>31.22</td>
</tr>
<tr>
<td>Intelligent Pedestrians Traffic Signal</td>
<td>7</td>
<td>4.29</td>
<td>30.05</td>
</tr>
<tr>
<td>ISA (Intelligent Speed Adaptation)</td>
<td>5</td>
<td>3.42</td>
<td>17.12</td>
</tr>
<tr>
<td>Red Light Camera/Speed Camera</td>
<td>4</td>
<td>4.02</td>
<td>16.09</td>
</tr>
<tr>
<td>Intersection Safety</td>
<td>4</td>
<td>3.82</td>
<td>15.26</td>
</tr>
<tr>
<td>Pedestrian Detection System and Automatic Braking</td>
<td>4</td>
<td>3.68</td>
<td>14.70</td>
</tr>
<tr>
<td>Trip Planning and Navigation with social network</td>
<td>4</td>
<td>3.55</td>
<td>14.19</td>
</tr>
<tr>
<td>PTW Oncoming vehicle info system</td>
<td>4</td>
<td>3.17</td>
<td>12.68</td>
</tr>
<tr>
<td>VRU Beacon System</td>
<td>4</td>
<td>3.16</td>
<td>12.64</td>
</tr>
<tr>
<td>Cyclist digital bicycle rear-view mirror</td>
<td>3</td>
<td>4.04</td>
<td>12.13</td>
</tr>
<tr>
<td>Roadside Pedestrian Presence</td>
<td>3</td>
<td>3.54</td>
<td>10.62</td>
</tr>
<tr>
<td>Urban sensing system</td>
<td>3</td>
<td>3.19</td>
<td>9.58</td>
</tr>
<tr>
<td>Bike on Public Transport information</td>
<td>2</td>
<td>4.36</td>
<td>8.72</td>
</tr>
<tr>
<td>Autonomous driving</td>
<td>2</td>
<td>4.03</td>
<td>8.07</td>
</tr>
</tbody>
</table>

Intelligent Pedestrian Traffic Signals are seen as one of the most promising ITS for pedestrians and cyclists. In this sense, it not only enhances VRU mobility, but also VRUs are less likely to cross during the red light phase. One of the experts claimed that on central urban areas, one of the big challenges for traffic management is to deal with the time shared in pedestrian crossings at junctions, since green light for pedestrians is red light for cars. In this sense, having this system available helps to ensure that pedestrians have sufficient time to cross, but also minimises the negative impact on the vehicle traffic-flow. The acceptance of this system by VRUs is considered high; since it responds to the need of pedestrians, especially elderly pedestrians and persons with reduced mobility, to be able to cross the road at their own speed. However, a negative aspect could be that drivers may perceive more frequent stops but these systems may skip cycles when there is no pedestrian crossing the road (anymore), which is likely to increase acceptance and compliance by the drivers.
Countdown traffic signals and pre-green for bikes are also included in this category. According to the experts, countdown traffic signals are requested by older road users to remove uncertainty over crossing times, claiming that it avoids red crossing. However, it should be adapted for different walking speeds.

According to the experts, this information benefits all: having a Countdown signal makes pedestrians feel safer at managing the crossing, it calms down drivers because they know how long they have to wait, and it helps the traffic flow because slower pedestrians will avoid starting to cross at the middle of the green light.

Pre-green for bicycles is also seen as promising in order to enhance safety and mobility of cyclists since they are clearly seen. Notwithstanding, drivers acceptance might be low and they might be surprised by green for bikes and still red for cars. One expert claims that this system is especially helpful when there is a significant amount of traffic on that road, but car drivers may block space for bikes and start driving when the signal for cyclists turns green.

Red light /speed cameras have, according to the experts, a great deployment potential, since pedestrians are struck whilst crossing a signalised crossing in some cities, even when the pedestrian light is green. This system is simple and cheap and is the only method of ensuring that traffic lights are obeyed. In addition, the payback period is short. Nevertheless, in places where it has been the norm to ignore red lights, rear-end shunts will be a problem in the short term. One of the challenges perceived by one of the participant authorities is “administrative issues”: the concern here was “if the authorities can issue fines, mail them, collect and enforce them in due time and necessary force” so that this measure is effective. Experts suggest that this system should be considered not only as enforcement but also a preventive action. One of the experts comments that this ITS might be perceived by drivers as a tax measure. To promote a change in attitudes and behavior the installation of red speed cameras is suggested.

Average speed cameras have been used successfully in UK to reduce drivers’ average speed. Experts suggest that its use should be extended, and that it should be combined with in-car information on speed limits. The aforementioned user needs analysis showed that drivers would appreciate having information about the speed limit on a regular basis.

Intelligent Speed Adaptation (ISA) is seen as a system that everybody benefits from. VRU acceptance is high, while drivers’ acceptance is lower. In this regard, the feasibility of ISA is considered technically high but politically low. As the authorities themselves recognise, there are definitely political issues there - but they go both ways, since on the one hand there is “the car culture” and the drivers’ “freedom”, but on the other hand there’s the safety and the legal speed limits. They point out the need to start in areas where driving slowly is indisputably a need, such as residential streets and school areas. According to them, a huge business opportunity for ITS providers lies in ITS for enforcement on a huge European market.

For PTWs, the system could be combined with curve warning, in addition to information about the surroundings (accident rates, infrastructure, current traffic flow, etc.). Previous research has however shown that there are negative attitudes towards ISA amongst rider groups (Simpkin et al., 2007; Nordqvist & Gregersen, 2011).

Pedestrian Detection Systems with Emergency Braking is seen by experts as safety enhancing with high acceptance by VRUs and a little bit lower for drivers. With regard to deployment potential, the first versions of these systems are already available on high-end vehicles. Regarding negative side effects, experts believe that rejection would occur only if there were many false alarms, which could additionally impose a risk to following traffic by unexpected harsh braking. Another participant says that the biggest risk is delegation of responsibility, and that the driver might compensate by being more reckless. In addition to detection of pedestrians and cyclists, experts see a good deployment potential in VRU Detection Systems for PTWs, especially in order to alert the driver of the presence of motorcyclists when entering an intersection.

Blind Spot Detection is considered by lots of experts as a promising ITS for the safety of VRUs, especially in supporting truck drivers when turning right and avoiding cyclists crashes. Besides, VRU acceptance is rated as high, but acceptance by drivers and authorities is lower. They suggest that drivers may worry about the loss of control, and there may also be the problem of drivers relying on this technology rather than checking mirrors.
They suggest that if legislation was used to make them mandatory then deployment would be easy. They suggest that the systems should not only detect, but also intervene.

VRU Beacon System acceptance might be low for VRUs according to the participants, but it depends on different factors such as power management of the beacon device. However, they consider it is quite feasible for children, and they can imagine it as being standard part of future cell phones. The way the device is introduced into the market should be reflected carefully. Experts suggest the use of tags for kids through infrastructure, such as bus stops, combined with warnings for both the bus driver, to inhibit the start at boarding and unboarding, and for other vehicle drivers to warn of children presence. According to the experts, beacons should indicate type of user, but that new icons may be difficult to comprehend. Regarding negative side effects, it may be difficult for the system to discriminate between “on boardwalk”/safe and unsafe conditions. In addition, traffic complexity is increased since traffic communication increases.

Oncoming vehicle information systems for PTWs, based on vehicle-to-PTW communication, is seen by experts as a “basic system for a complete ITS-safety system for all road users”. However, they think that it should be safe against hackers. It is considered to have deployment potential, as well as being appealing to road authorities. The usability issues are of critical importance, and drivers may choose to switch off/over-ride system.

Intersection Safety, based on infrastructure-to-vehicle communication, has the potential to enhance safety and mobility of cyclists, pedestrians, and PTW riders. With regard to PTW riders, experts mention the option of combining intersection support systems that detect PTW riders, and flashing lights in the PTW to increase conspicuity.

Trip planning and navigation with social network: this service should be adapted to the needs of VRUs, elderly and disabled included. As a negative side effect they mention excess of confidence (outdated or erroneous map information), and possible distraction when checking the screen.

7. Conclusions

The deployment of ITS technologies has the potential to enhance safety and mobility of VRUs. However, it is essential for their success, that these systems are tailored to the specific needs of road users. For this reason, the current investigation has begun with the identification of the critical scenarios for VRUs as well as user needs, in order to find the most promising ITS systems to address them, according to a group of experts.

Based on information derived from Focus group discussions, junctions are one of the most relevant critical situations for VRUs, where VRUs are endangered due to being hardly visible or easily overlooked. Moreover situations where cars overtake cyclists or PTWs are especially assessed as being critical due to high traffic speeds and the perceived reckless behaviour of car drivers in some cases.

Data obtained from Focus Group discussions indicated that the visibility of VRUs is generally perceived as a major factor in view of traffic safety, especially in connection with heavy traffic and high speed situations. Correspondingly technologies and systems enhancing the detectability and visibility of VRUs are considered to have high potential to increase the traffic safety of VRUs.

Previous research has pointed out that ITS technologies capable of distinguishing between different types of VRUs and of rapidly deploying tailored countermeasures (such as active braking or airbags) to reduce injuries in the event of a crash offer considerable safety potential (Regan et al., 2001). A detailed study on the potential of Pedestrian Detection Systems/Emergency Braking, suggests that 40% of fatalities and 25-30% of severe injuries suffered by pedestrians can be avoided (Källhamer, 2009). Similarly, Blind Spot Detection systems are seen as promising, especially to avoid truck-cyclist crashes.

Cooperative systems, based on simple beacons carried by VRUs, or two-directional devices allowing communication between PTWs and vehicles, are seen as having a great potential. In this sense, the multitude of
sensors and communication interfaces smart phones deliver, together with their rising penetration, could provide a good opportunity to improve the visibility of VRUs in complex/urban environments. Indeed, focus group discussions revealed that smartphone-based applications (for routing and navigation) are regularly used by all involved road user groups.

Regarding PTW’s the potential for vehicle-to-PTW communication systems to address motorcycle conspicuity issues has been previously recognised (Bayly et al., 2006), though one issue to tackle is the need to reach the necessary penetration to achieve efficiency of cooperative systems. However, while on the one hand systems supporting visibility or communication between PTW’s and cars are considered very positive, on the other hand ITS interfering with the riding task or those perceived to take away the autonomy from the rider are seen as very sceptical. Training and education are considered to be of major importance in this group with ITS having mainly adverse effects on riding behaviour. This is in line with the research of Beanland et al. (2013), who found that riders believe that innovations should focus on protective equipment, rather than systems that prevent crashes; since they believe crash prevention is better addressed through rider training.

In this sense, Huth & Gelau (2013) found that the social norm and the interface design are powerful predictors of the acceptance of Advanced Rider Assistance Systems (ARAS), while the extent of perceived safety when riding without support did not have any predictive value in their study. Thus, these authors found that the specific social influence of peers confirmed for the acceptance of ADAS (Arndt & Engeln, 2008) had proven to have a strong influence on the acceptance of ARAS in their study. This finding revealed the impact that preconceptions regarding the support systems, which might be present in rider circles, may have on the acceptance of the ARAS by an individual. Accordingly, it lends importance to promoting a favorable attitude towards such solutions amongst motorcycle riders, with the particular aim of avoiding a distinctly negative social norm (Huth & Gelau, 2013). According to PTW’s participants in focus group discussions, there are not really specific ITS solutions for motorcycles. Several researchers have reflected this need for assistive systems to be developed specifically for PTW’s (Bayly et al., 2006; Beanland et al., 2013). The need of a better understanding of people’s attitudes and opinions about ITS applications has been highlighted as an important area for further research (Regan et al., 2001), especially given the rapid rate at which ITS applications are becoming available. As Van der Laan et al. (1997) stated, it is counterproductive to invest in developing new technologies if the systems are never purchased or if they are purchased but never used. In other words, these systems can only enhance users’ safety and mobility if they use them. For this reason, acceptance is a decisive aspect to be considered in the development process of such systems. In the present study on user needs, overall willingness to use ITS for VRUs and the assessment of benefits for traffic safety and general mobility was assessed on a very high level by both experts and focus group participants. Actual acceptance was found to be mainly related to the following factors: Price/affordability, usability/implementation, availability, standardization across different platforms and manufacturers, reliability, and privacy.

On the other hand, too high vehicle situational speeds have been repeatedly found to be a very important factor in fatal pedestrian collisions. It is well known that even small decreases in vehicle travelling speeds prevent a large number of pedestrian fatalities. For this reason, Intelligent Speed Adaptation as well as automated speed enforcement have significant potential to reduce the injury consequences of VRUs crashes. Red Light Cameras are seen as a safety enhancing technology, and with great deployment potential. However, promoting a change in attitudes and behaviour is suggested in addition to the installation of the Red Light Cameras. In this regard, enforcement should be accompanied by educational measures in order to modify intentions to break the law.

Intelligent Pedestrian Traffic Signals are seen as promising ITS for pedestrians, including elderly and disabled, and cyclists. It provides pedestrians with the amount of time they need to cross at the speed they are capable of, this being fundamental for all pedestrians, namely the elderly and those with reduced mobility. In this sense, it not only enhances VRU mobility, but also VRUs are less likely to cross during the red light phase.

Starting from the list of applications identified by the experts, the VRUIITS project will assess the impact of applications on safety and mobility on Vulnerable Road Users. In a first phase the direct and indirect effects of the functions will be determined, in a second phase the impacts on safety and mobility and the socio-economic impact will be assessed. The assessment will be basis for recommendations for policy and industry on measures regarding ITS applications to improve the safety and mobility of VRUs.
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