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Can cyclist safety be improved with intelligent transport systems?

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ABSTRACT

In recent years, Intelligent Transport Systems (ITS) have assisted in the decrease of road traffic fatalities, particularly amongst passenger car occupants. Vulnerable Road Users (VRUs) such as pedestrians, cyclists, moped riders and motorcyclists, however, have not been that much in focus when developing ITS. Therefore, there is a clear need for ITS which specifically address VRUs as an integrated element of the traffic system. This paper presents the results of a quantitative safety impact assessment of five systems that were estimated to have high potential to improve the safety of cyclists, namely: Blind Spot Detection (BSD), Bicycle to Vehicle communication (B2V), Intersection safety (INS), Pedestrian and Cyclist Detection System + Emergency Braking (PCDS + EBR) and VRU Beacon System (VBS). An ex-ante assessment method proposed by Kulmala (2010) targeted to assess the effects of ITS for cars was applied and further developed in this study to assess the safety impacts of ITS specifically designed for VRUs. The main results of the assessment showed that all investigated systems affect cyclist safety in a positive way by preventing fatalities and injuries. The estimates considering 2012 accident data and full penetration showed that the highest effects could be obtained by the implementation of PCDS + EBR and B2V, whereas VBS had the lowest effect. The estimated yearly reduction in cyclist fatalities in the EU-28 varied between 77 and 286 per system. A forecast for 2030, taking into accounts the estimated accident trends and penetration rates, showed the highest effects for PCDS + EBR and BSD.

1. Introduction

The state of the road user, the vehicle and the traffic environment are often considered to set the baseline of the safety situation for road users (Evans, 2004). According to Risser's Diamond model (Lundälv et al., 2009), this baseline should also include social structures and communication. The Diamond model was successfully applied to evaluate and develop cycle police patrols in Helsinki on a strategic, tactical and operational level. It was concluded that police cycle patrols are an efficient means to enhance safety and security in European cities. Intelligent Transport Systems (ITS) can make the concept even more comprehensive. There are a lot of models with which to explore the safety situation in more detail; one is the multiple comfort model proposed by Summala (2005) and modified by Leden (2007) to fit this purpose. According to the model, the following five issues are the most important ones to explain road user behaviour on a strategic, tactical and operational (individual) level: safety margins (to survive), good or expected progress of trips, rule following (according to the law and social rules), vehicle/road system (bicycle and infrastructure) and pleasure of driving and pleasure of cycling.

1.1. Safety margins

Safety margins imply a concept of available time. It is, for example, important to make cyclists and cars visible to each other, for instance through warning lights, signs or messages in the infrastructure or in-vehicle alarms to warn of conflicting road users. Otherwise, especially in darkness, safety margins tend to be insufficient. Adaptive lighting at pedestrian and cycle crossings increases the road lighting when a vulnerable road user intending to cross is detected. In critical situations, combined pedestrian detection systems and emergency braking could be desirable.

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1.2. Good or expected progress of trips

Good or expected progress of trips is an important issue for cyclists. Cyclists like to maintain their speed and may hesitate when it comes to braking. Therefore, detectors located well in advance of signalised intersections give cyclists the possibility to get a green light without having to slow down or dismount. Gradients, especially downhill, are hazardous for cyclists as they are reluctant to brake, see e.g. Leden (1989).

1.3. Rule following

The analysis of Finnish in-depth crash data revealed that 80% of cyclists had not obeyed some rule (Schepers, 2015). Though this figure is certainly biased since the conclusions often derive from a surviving car driver's statements, rule following is obviously critical also for cyclists. Laws and regulations should enhance and secure communication between road users. Harmonization of rules within the EU is an important issue. For example, in southern and eastern Europe there is a ban on phone use while cycling. In northern Europe there is no such ban, except in Denmark (Schepers, 2015).

1.4. Vehicle/road system (bicycle and infrastructure)

According to Summala (2005), the vehicle/road system for cars usually implies smooth car/road performance. This is often not the case for the cycle/road system. Adequate bicycle infrastructure is often missing in Europe, except in the Netherlands and Denmark, and if it exists it often does not comply with the best practice (Leden, 1999). A cycle design for e.g. elderly cyclists based on new technology is lacking. One of many issues could be to implement a bicycle-to-car communication system to facilitate communication between road users. ITS could be a way to improve the safety of cyclists for example at intersections through early detection and prioritizing of vulnerable road users.

1.5. Pleasure of cycling

Pleasure of cycling is an important topic especially for senior cyclists, as 84% of the respondents stated that joy is a reason for them to cycle (Leden, 2008). Therefore, the measures to be implemented should keep or increase the pleasure, and the amount, of cycling. Examples of such ITS based measures are a green wave for cyclists and information on bicycle rack vacancies. Overall, it is important to note that an increase in cycling (e.g. due to use of ITS) means more fatalities and injuries for cyclists if adequate conventional or ITS based countermeasures are not taken, even though the risk per cyclist decreases (Leden, 1999).

1.6. background and objectives

The current safety situation for cyclists within the EU is alarming. In 2012 over a hundred cyclists were killed in each of the following countries: Denmark, Portugal, Italy, France, Romania, the Netherlands and the UK. Also in 2012, in total 2071 cyclists were killed in the EU (European Road Safety Observatory, 2015). Thus the need for countermeasures to improve the safety of cyclists is urgent.

In recent years, ITS have assisted in the decrease of road traffic fatalities, particularly amongst passenger car occupants. Vulnerable Road Users (VRUs) such as pedestrians, cyclists, moped riders and motorcyclists, however, have not been that much in focus when developing ITS. Therefore, there is a clear need for ITS that specifically address VRUs as an integrated element of the traffic system.

This paper presents the results of a quantitative safety impact assessment of five systems that were estimated to have high potential to improve the safety of cyclists, namely: Blind Spot Detection (BSD), Bicycle to Vehicle communication (B2V), Intersection Safety (INS), Pedestrian and Cyclist Detection System + Emergency Braking (PCDS + EBR) and VRU Beacon System (VBS).

The overview of systems is presented in Table 1 showing for each system the VRU groups that are addressed and the targeted accidents.

The objective of this study was firstly to determine the impact mechanisms through which the selected ITS services affect the safety of cyclists. A second aim was to provide quantitative estimates for the safety impacts of the selected ITS in the EU-28 when they are fully deployed and for selected future scenarios (2020 and 2030). An ex-ante assessment method has been suggested by Kulmala (2010) to provide traffic safety impacts of ITS. The method has been used in expert assessments of ITS for cars. The same approach was applied and further developed in this study to assess the safety impacts of ITS specifically designed for VRUs.

2. ITS improving the safety of cyclists

2.1. Selection of systems

First, a list of 23 ITS was drawn up. This included all ITS that were deemed to be near to market and to have good potential to improve the safety, mobility and/or comfort of VRUs. Subsequently, the impacts of these systems on safety, mobility and comfort were assessed qualitatively (Scholliers et al., 2014), and based on this a subset of 10 ITS was selected for quantitative assessment. This selection was done in a workshop, using a multi-criteria assessment and portfolio check (ex-post check on the overall result) (Kruijff and Malone, 2014). The multi-criteria analysis ranked the systems whereas the portfolio check determined whether all important aspects were covered. The multi-criteria selection included issues such as benefits, costs, deployment and users whereas the portfolio check confirmed, for example, that the systems addressed all vulnerable road user groups, covered all impact categories, and covered different types of ITS (infra-based, car-based, VRU-based and cooperative ITS).

Five of these ten systems were estimated to have a large effect on cyclist safety and were hence selected for the assessment presented here: BSD, B2V, INS, PCDS + EBR, and VBS. These systems are presented in more detail in Section 2.2 of this paper. Of the remaining five systems, Green Wave for Cyclists (GWC) and Information on Vacancy of Bicycle racks (IVB) are meant for cyclists but do not primarily concern traffic safety, while Crossing Adaptive Lighting (CAL), Intelligent Pedestrian Traffic signals (IPT) and Powered-Two-Wheeler to Vehicle Communication (PTW2 V) address pedestrians, moped riders and/or motorcyclists but not cyclists.

2.2. Description of systems

A short description of each assessed system is included below, together with pictures illustrating their performance (Fig. 1).

2.2.1. Blind spot detection (BSD)

The system uses vehicle sensors to detect cyclists and mopeds in blind spots near cars, trucks and buses. The system addresses mainly the side areas of the car/truck/bus, but optionally also the front and rear. Upon detection the system provides a warning to the driver, but does not intervene. The system aims to prevent accidents with cars, trucks and buses and VRUs in the blind spot of the car/truck/bus (the blind spot can be on either side of the vehicle).

2.2.2. Bicycle to vehicle communication (B2V)

The system informs and warns the driver about cyclists on the road in the vicinity of the vehicle, and the cyclist of potential col-

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