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From technological acceptability to appropriation by users: Methodological steps for device assessment in road safety

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ABSTRACT

This article presents the methodology developed within the framework of the research project SARI (Automated Road Surveillance for Driver and Administrator Information). This methodology is based on the logic of action research. The article presents the different stages in the development of technological innovation addressing vehicle control loss when driving on a curve. The results observed in speed reduction illustrate that no matter how optimal an innovation may be technologically speaking, it is only as effective as it is acceptable from a user standpoint. This acceptability can only be obtained if the technology is developed by engineers in liaison with social science specialists.

1. Introduction

The objective of this article is to present a research methodology based on action research logic, as it was applied in SARI (Automated Road Surveillance for Driver and Administrator Information). This methodology has made it possible to obtain results convincing enough to give rise to significant modifications in actual driver behavior. The SARI project took place from 2005 to 2010 and involved thirty-six laboratories and technical centers, eleven companies and three local authorities.

1.1. Issue of SARI

The objective of SARI was to study the possibility of new technological solutions to road security problems. This project took place in a particular context: a major road safety risk on rural roads (i.e., network outside urban area), a constrained resource budget and the need to find new solutions to road safety problems. In 2004 (before the project began) accidents on rural roads accounted for 38% of personal injury accidents in France. However, they represent 73% of fatal accidents, or 3781 deaths (out of the 5232 accounted for in mainland France) (ONISR, 2005). The severity (deaths/100 injuries) was also 3.9 times higher on rural roads than in urban areas.[1] Moreover, rural roads were also subject to the biggest budget constraints due to being managed by local communities and not the French State. Therefore, it was not possible to improve road security by rebuilding roads. New solutions had to be found. Considering the analyses carried out on potential sources of road safety measures

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[1] Thanks to the various actions carried out within the framework of PREDIT (French program of research, experimentation and innovation in land transport) and consistent political goodwill, the latest figures are 3963 road deaths, of which 2867 happened on rural roads (2011 data-ONISR, 2012).

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(Guyot, 2002), the choice was to work on the interaction between drivers and infrastructure.

Even if human error is responsible for 90% of road accidents (Dewar and Olson, 2002; Wegman, 2007), they result from the interaction between the driver and the external conditions of the driving task (Van Eslande, 2003). Moreover, road infrastructure configuration plays a part in about 30% of these accidents (Rumar, 1985). Similarly, the influence of road layout on drivers' behavior is emphasized by Saad (1988, 1992). "So it appears that it is often the situation that is primarily responsible for the failure of the driver, not his responses themselves. The idea is that these failures can result from a misleading perception of the environment induced by the road configuration and the environment" (Rosey, 2007, p.5). Drivers are therefore facing problems of complexity, visibility, legibility and so on (Van Elslande et al., 1997). Consequently, the aim of the research carried out in SARI was to develop new roadside technological solutions allowing for a reduction in accidents caused by vehicle control loss by warning drivers of any approaching adverse driving conditions that they might poorly perceive or not perceive at all. The aim was to correlate the risk of vehicle control loss with road characteristics in order to define the relevant information for drivers, making them switch from and ordinary state of attention to a state of alert, thus changing their behavior. SARI was composed of four work packages: three technical work packages (dealing with vehicle control loss) and one human work package called AJISE (for legal, individual, social and economic acceptability).

1.2. Methodology developed in SARI

The goal of this article is to present the methodology developed in SARI by means of the research work carried out on vehicle control loss in curves.[2] This methodology is based on a technological development stemming from a close collaboration between engineering (technical work packages) and social sciences (human work package). The system needs to meet optical technological conditions, but also be designed for user appropriation. In other words, it is necessary for the system to be acceptable (see for instance Lefeuvre et al., 2008; Lefeuvre and Somat, 2005; Lheureux, 2009; Molin and Brookhuis, 2006; Pianelli, 2008; Terrade et al., 2009). Acceptability can be defined as the degree of integration and appropriation of an object, in a context of use (Barcenilla and Bastien, 2009; Venkatesh and Bala, 2008).

The present research falls in line with action research logic as defined by Lewin: "a comparative research on the conditions and effects of various forms of social action and research leading to social action [. . . that uses] a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action" (1946, pp. 35 and 38). This article presents the different "spirals of steps" put in place to accompany the development of the technological solution while taking the human factor into account. These experiments were the subject of full-scale testing on real roads.

2. Spiral 1: Development of a technological solution

2.1. Planning: diagnostic method

In order to reduce the risk of accidents due to loss of vehicle control from physical disruptions on the road that are well-known sources of accidents (Brenac et al., 2000; McGee and Hanscom, 2006; Michel et al., 2005; Orfila, 2009; Sétra, 2002) the project team decided to develop a diagnostic method in order to find a pertinent technological solution to this problem. Two complementary approaches were used: the first one consisted in measuring users' trajectories on the infrastructure by video systems and roadside installed electromagnetic loops (called observatory of trajectories)—this observatory was developed as a part of this research project; the other one used an "innovative vehicle of diagnosis" to measure the stress on the vehicle at different speeds.

2.2. Action

After the analyses of several curves selected from real roads in the French administrative department of Côte d'Armor, one curve was chosen based on accident risk criteria. A diagnosis made it possible to identify and quantify the limiting trajectories of vehicles in the curve (particularly, the critical threshold speed). Based on the characteristics of the curve (curve radius, superelevation, slope, evenness), an estimate of the risk of vehicle control loss was calculated and used to develop a warning system able to inform the user of the lane departure risk for a given speed. The idea was to warn the user of a potential danger based on his speed approaching the curve (the warning applies only to individual users whose approaching speed is too high). Knowing speed profile (approach speed and threshold speed), it was possible to create an individualized alert from the approach speed of the vehicle. It is based on measuring the approach speed far enough before the curve for the driver to react on time. Based on previous work by the CETE-Normandie-Centre (2000), the approach area is estimated at 200 m for the selected curve given that user deceleration in this area is generally low or very low. With models that link speed and geometric characteristics of curves (Louah et al., 2008; Sétra, 1986) the "safe" speed to clear the curve is estimated at 70 km/h. This value is confirmed by passages done with the "diagnostic vehicle" showing that for this speed (70 km/h), lateral acceleration reaches a threshold of 3 m/s^2 that is considered by most users as the acceptable limit in terms of comfort. Finally, the location of the speed detection was determined by a simple kinematic study which takes into account a reaction time equal to two seconds, an approach speed of the fastest users equal to 102 km/h, a "safe" speed in the curve equal to 70 km/h and a deceleration accepted by users equal to 2 m/s^2. It was set at about 150 m before the curve. Considering all these criteria, the speed used to trigger the warning device is fixed at 93 km/h (V85). Furthermore, this speed corresponds to an activation of the alert system for approximately 15% of the fastest users approaching the bend.

The choice of signaling media was based on an analysis of the literature about the necessity for a low-cost solution and on the operational feasibility. The literature showed that road signing was poorly perceived or not perceived at all (at least not consciously) (Drory and Shinar, 1982; Hughes and Cole, 1984; Shinar and Drory, 1983; Sprenger et al., 1999), which incidentally led certain authors to question the real effectiveness of road signing (Fischer, 1992; Johansson and Backlund, 1970; Knowles and Tay, 2002; Macdonald and Hoffmann, 1991; Summala and Hietamäki, 1984). As for other authors, they underlined the importance of context when considering signing awareness (Bazire et al., 2004; McKelvie, 1986) and individual risk perception as decisive criteria (théorie de l'homéostasie du risque, Wilde, 1994). But fixed signs, put in place to inform all drivers in all situations of a danger regardless of their driving behavior, are a matter of obeying the law rather than a decisional aid. All these factors taken into consideration, dynamic road signing would appear not only to be a means of alerting the driver, but also making him change from an automatic to a controlled behavior (Ranney, 1994); additionally, it would better inform him of the real risks than fixed signing would. The choice came down to flashing lights; this solution had

[2] Two other control loss types were studied (loss related to adverse weather conditions and loss related to visibility problems); these studies will not be presented here.