

# COOPERATIVE SYSTEMS FOR VULNERABLE ROAD USERS: THE CONCEPT OF THE WATCH-OVER PROJECT

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## ABSTRACT

The WATCH-OVER project, coordinated by Centro Ricerche Fiat, starting its activity in 2006, is a European project co-funded by the European Commission Information Society and Media within the initiatives of the cooperative systems for traffic safety and efficiency based on communication and sensor technologies. The core concept, presented in this paper, is to avoid road accidents that involve vulnerable users such as pedestrians, cyclists and motorcyclists in urban and extra-urban areas, the system concept will be based on interactions between an in-vehicle module and users' devices.

## KEYWORDS

vulnerable road users, cooperative systems, communication technologies.

## INTRODUCTION

In line with the European policies, the problem addressed in the WATCH-OVER project is linked to road safety issues; it focuses on the huge number of road accidents that involve vulnerable users like pedestrians, cyclists and motorcyclists. Data available in the OCSE data bank show that in the year 2002 in Europe-15 around 15.000 pedestrians, cyclists and motorcyclists died in road accidents, thus being around one third of the total fatalities. Additionally, statistics indicate that about 150.000 pedestrians are injured every year (and 6,000 are killed) in accidents that occur in urban areas.

The WATCH-OVER project aims are in line with the specific objective stated in the 2005-6 Work Programme of the European Commission “Information Society Technology”, and more precisely to the objectives:

*“to develop and demonstrate Co-operative systems for road transport that will make transport more efficient and effective, safer and more environmentally friendly. Such systems will enhance the support available to drivers and other road users and will provide for increased safety by improving the quality and reliability of information used by advanced driver assistance systems and allowing the implementation of advanced safety applications”*

as the WATCH-OVER project is aiming to work on the design and development of an efficient and low cost vehicle-vulnerable users cooperative system based on advanced communication technologies. The project, co-funded by the European Commission and supported by EUCAR, includes in its consortium vehicle and motorcycle makers, technology, automotive suppliers and research centres for its development and testing phase.

The project will carry out research and development activities aimed to the design and development of a system for the prevention of accidents involving vulnerable road users in urban and extra-urban areas. The current sensor technologies cannot “see” behind obstacles and have a limited view of the lateral and of the longitudinal areas, therefore limiting the operational scenarios of the system. In fact, the main difficulty in detecting vulnerable users is the limited “visibility” of car and truck drivers and of in-vehicle sensor based systems. Additionally, the complexity of the traffic scenario presents a number of cases in which vulnerable users are suddenly getting out from an area that is covered by the infrastructure or by other vehicles. Hence no sensor based systems are able to perform a preventive detection in all different scenarios.

Two European funded projects, PROTECTOR and SAVE-U, had been working on the prevention of accidents involving vulnerable road users, both initiatives had as main objective the investigation, in terms of technological feasibility, of systems based on in-vehicle sensors. The two projects evaluated different sensor technologies: microwave radar, laser-radar, near and far infrared, mono and stereo vision, etc. the final outcomes is however that the extent to which these technologies are applicable is limited to those scenarios in which the vulnerable users are not hidden by obstacles or are not in a “blind area” of the sensors.

The WATCH-OVER approach is focused on the cooperation between in-vehicle modules and devices inserted in wearable objects (like helmets, shoes, watches, consumer electronics) or integrated in motorcycles.

The project activities foresee the adaptation of low cost communication technologies, in combination with the most promising sensor technologies, to cover the most critical road scenarios. The idea behind this approach is that a cooperative system shall guarantee:

- a wider scenario coverage including blind spots,
- simple and low cost on-board systems,
- a flexible and open architecture.

## COMMUNICATION AND SENSOR TECHNOLOGIES FOR VEHICLES AND VULNERABLE USERS

The core of the system is the interaction between an on-board module and a user module, interaction which exploits innovative wireless short range communication technologies as an extension to vehicle autonomous systems. The cooperative low cost platform will extend the actual coverage of the state of the art technologies and will be open to integrate localization technologies. The main challenge of project activities is to face the different urban and extra-urban scenarios that involve a huge variety of vulnerable users in very different conditions. Thus the system on-board is conceived to enable the following functionalities:

- real-time detection of pedestrians, cyclists, motorcyclists equipped with the WATCH-OVER module,
- calculation of the relative positioning of the user vs. drivers (relative motion analysis),
- detection of dangerous situations (external scenario reconstruction, filtering specific situations),
- appropriate warning to the driver, providing information only in really dangerous situations,

while the vulnerable road user module is conceived to:

- promptly answer to vehicle's stimulus, delivering its identification parameters,
- send back self-localization parameters,
- give feedbacks to the road user with an appropriate interface.

In particular a set of wireless short range candidate technologies will be examined, both state of the art and on going developments, with the aim to identify a subset of them suitable for the use in the users' detection mechanism. The specificity of the application requires devices' adaptation to face the different road scenarios. The selection of the interaction technologies, from a technical point of view, will be done taking into account the most relevant features, among which:

- communication parameters (ranges, delays, robustness, etc.),
- electromagnetic, radiation characteristics (scenarios will be tested in specific testing environments),
- localization capabilities.

The sensing part of the WATCH-OVER system will focus on the short-range and would rely on a Near Infra-Red CMOS-camera, with active Infra-Red Headlamps, to obtain both day and night-time capabilities. In terms of methodologies, the vision component in the project will rely on fast motion cues for the fast detection of lateral pedestrian movement. In general, detection and classification algorithms [Gavrila2004] need to be adapted to work on NIR image data.

In respect to previous European project on pre-impact pedestrian sensing, SAVE-U [SAVE-U2005], WATCH-OVER aims to sensibly reduce the number of false potential obstacle detection,

A thorough analysis of the short range wireless communication technologies (WI-FI, Bluetooth, RFID, UWB etc.) led to the pre-selection of the candidate technologies briefly described hereafter.

The Ultra Wideband (UWB) communication systems typically use signals with bandwidths of several GHz. There are different ways of generating the signals, including direct sequence spread spectrum, frequency modulation, and multi-carrier approaches. One of the most common method called "Impulse Radio" (IR), uses extremely short pulses (pulse duration < 1 ns) to transmit data without using an RF carrier wave. The properties of UWB signals allow positioning at cm-accuracy. For the detection and localization of vulnerable road users, the use of a UWB differential impulse radar scheme is proposed. This method has the following benefits:

- low power consumption,
- low cost wearable unit,
- exact estimation of the distance,
- high reliability of the signal recognition.

The IEEE802.15.4 standard has been published in October 2003, first Silicon products are now available, the IEEE802.15.4 operates in the 868/915MHz or in the 2.4 GHz, with data rates of up to 250 kb/s. The main characteristics are:

- low power consumption,
- fast wake-up and association,
- bi-directional communication,
- availability of network management and supervision functions,
- solid modulation through spread spectrum technologies,
- low cost,
- low complexity of transceiver control.

The RFID's performances vary depending on external circumstances, i.e. the influences of metallic materials and different environments play an important role. The selection of the tag depends on the functionality, there are passive and active tags and the frequencies to be used in the project will be defined depending on the requirements. It is foreseen to use active tags, as a relatively long distance is needed for a timely interaction between the vehicle and the vulnerable road users. Passive tags are, in fact, inexpensive objects, they don't need an autonomous energy source, but they cover only short distances, the active tags have longer ranges, but relative high costs and need an autonomous energy source.

Another relevant issue for the choice of the tags is the transmitting frequency the system has to operate on. RFID can operate on four frequency bands: Low Frequency at 125 KHz, High Frequency at 13.56 MHz, Ultra High Frequency at 868-956 MHz and Microwave at 2.45 GHz. On this issue it has to be noted that the UHF band is not standardized, this creates compliance problems when using a chain of RFID scanning events around the world, like in a supply chain. Suppliers are trying to solve this problem by making tags that can be read via different frequencies, this is important as UHF is growing in popularity in RFID use, the advantage of this frequency is a quite large distance of scanning and reading also with passive tags.

## THE WATCH-OVER SYSTEM CONCEPT

The WATCH-OVER activities are focused on the design and development of an integrated cooperative vehicle-user system for the prevention of accidents involving vulnerable road users in urban and extra-urban scenarios. The architecture is based on the use of most promising communication technologies in combination to most promising vision sensor technologies. In view of future exploitation in short to medium term, following targets will be pursued: high reliability of signal recognition in each scenario, effective strategies of warning and/or of intervention, low cost and low power consumption of components.



Fig. 1 – The variety of scenarios for which the WATCH-OVER system will be designed.

The design of the WATCH-OVER system will be in view of the following performances:

- extension of the “protection concept” by effective driver warning and vehicle braking strategies,
- increased vehicle speed range (up to 50 km/h) at which the system is operable,
- high reliability and timely performances related to the detection and localization of the vulnerable road users,
- low cost sensor and communication technologies,
- increased processing speed (more than 10 Hz),
- increased sensor coverage (0–20m).

Specifically, the WATCH-OVER vulnerable road user platform is expected to be able to:

- promptly answer to vehicle’s stimulus delivering its identification parameters,
- send back a few self-localization parameters,
- give feedbacks to the road user with an appropriate HMI.

The WATCH-OVER application (the vehicle with the on board control unit, the image sensing and communication modules, the wearable module including communication technology) implemented and integrated in three demonstrator vehicles (two cars and one motorcycle) will be tested to verify technical performances and user acceptance. For complex scenarios simulation tools will be used.

## CONCLUSIONS

The WATCH-OVER European project aims at designing and developing an integrated cooperative system for the prevention of accidents involving vulnerable road users in urban and extra-urban areas. The core of the system is the interaction between an on-board module and a user module, interaction which exploits innovative wireless short range communication technologies as an extension to vehicle autonomous systems. The cooperative low cost platform will extend the actual coverage of the state of the art technologies and will be open to integrate localization technologies.

The main functionalities which will be supplied by the WATCH-OVER on-board platform are the real-time detection of pedestrians, cyclists, motorcyclists, the relative positioning of the user vs. drivers (relative motion analysis), the identification of dangerous situations, the appropriate warning to the driver.

In particular a set of wireless short range candidate technologies will be examined to identify a suitable set for the use in the users' detection mechanism. The specificity of the application requires devices' adaptation to face the different road scenarios. The selection of the interaction technologies, from a technical point of view, will be done taking into account the most relevant features.

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