FROM USER NEEDS TO APPLICATIONS: THE SAFESPOT APPROACH BASED ON ROAD ACCIDENT DATA ANALYSIS

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ABSTRACT

The Goal of the SAFESPOT Integrated Project is to understand how intelligent vehicles and intelligent roads can cooperate to produce a breakthrough in road safety. The system should extend in space and time the driver's awareness of the surrounding environment and detect in advance the most potentially dangerous situations. Wireless communication, vehicle-to-vehicle and vehicle-to-infrastructure, are used to exchange information and warning in real time. This paper presents how a detailed road accident data analysis in European countries was used to design the infrastructure-based applications of the system. The potential impact of the system in terms of safety is also presented.

KEYWORDS

Driver Safety Assistance, Vehicle-to-infrastructure communication, Design.

INTRODUCTION

The permanently growing demand for mobility of peoples and goods leads to huge socio-economic costs in terms of accidents with serious injuries every year. It is a matter of common knowledge that therefore one of the major objectives of the European Union is to halve this number of accidents by 2010. The 6th European Framework Program promotes a huge portfolio of projects in order to achieve this challenging goal; one of these is the Integrated Project SAFESPOT.

Looking at the course of an accident you can distinguish between the phases before the crash itself, the pre-crash, and the post-crash phase. Therefore different safety approaches can be characterised.

After the accident has occurred, it is necessary to reduce the time until emergency assistance arrives therefore an advanced eCall-System is mandatory. During the crash, passive safety systems like safety belts and airbags are used to reduce the accident consequences to the vehicle occupants. The European Project APROSYS (Advanced Protection Systems) deals with this topic. The PREVENT Project focuses on the objective to increase the active safety in order to support advanced driver assistant systems. The CVIS project focuses on increasing efficiency in the road network. In contrast, SAFESPOT will mainly be applied to the critical situations, “black spots”, whose danger is quantified by statistical accident data analysis, to produce a breakthrough in road safety.

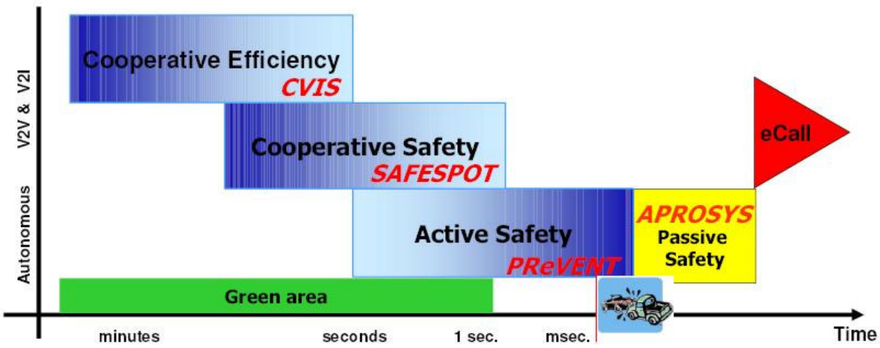

Figure 1 - Time-to-crash of the SAFESPOT approach

By combining data from vehicle-side and road-side sensors, the SAFESPOT applications will allow an extension of the time in which a potential accident is detected before it can occur, from the range of “milliseconds” up to “seconds”, as shown in Figure 1. The transmission of warnings and advices to approaching vehicles, by means of vehicle-to-vehicle and vehicle-to-infrastructure communications, will extend in space and time the driver’s awareness of the surrounding environment.

This paper presents the process which has been made within the project by working out suitable applications from a road user point of view. It presents how a detailed road accident data analysis in European countries was used to design the co-operative safety infrastructure-based applications of the system. A number of use cases are described to illustrate how the “Safety Margin Assistant” of SAFESPOT shall act to detect in advance dangerous situations. The potential impact of the system in terms of safety is also presented.

THE DESIGN METHODOLOGY

For designing safety applications based on co-operative sensing technologies, a user-centred approach was adopted. The user needs explain what the system is expected to provide, and the constraints under which it must operate. Parallel to the definition of the user needs there was an extensive analysis of the accident data. The analysis was separated in three driving environments: the urban area, motorways and rural area for different European countries in order to find out what the most relevant safety scenarios are. This is necessary in order to customize the applications to the needs and to derive a high benefit at the end. The Figure 2 below shows the used methodology in an overview.

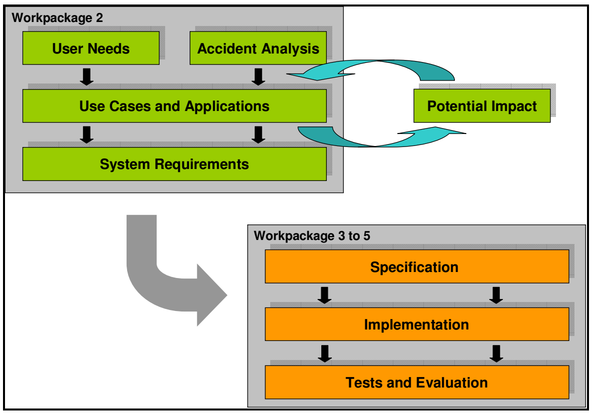

Figure 2 - The SAFESPOT design methodology

Based on the accident analysis and the user needs, the use cases and scenarios are drawn to generate a first picture of the usage of the applications. During this process twenty four use cases were described, concerning the above mentioned driving environments and classified on different topics: 'Obstacles', 'Misjudgement', 'Rule violation', 'Critical environment conditions' and 'Collision avoidance'. Then primary requirements of the system were derived from these use cases. Based on a more complete and detailed description of the applications that should cover the use cases, the system engineers have completed the requirements list, and provided the functional characteristics of the system. To validate the applications, the analysis of their potential impact in term of safety has been achieved, and has given interesting results to optimize them.

After this first phase of the SAFESPOT project the specification phase will follow; then there will be the implementation phase and the evaluation of the applications. The evaluation will be carried out on several test sites located in six European countries.

A DETAILED ACCIDENT DATA ANALYSIS TO INVESTIGATE CRITICAL SITUATIONS

The accident data available at a European level form the Eurostat institute, the CARE and EACS databases, or the SAFETYNET, RANKERS or PENDANT projects provide an overview of the European accidentology. They highlight main similarities or differences between countries, and confirm that rural, urban or motorway areas have different accidentology characteristics. The distribution of accidents in those areas mainly follows the average values of figure 3. The other details available are mainly based on criterions like the age, the gender or the day of the week, but they don't provide further details as they are not available in all European countries or not gathered in the same way.

Indicators Vs Classification	Accidents	Injury	Death	Risk level [1]	Mortality index [2]
1st	Urban – 75%	Urban – 70%	Rural – 55%	Urban (0.57 – 1.10)	Rural – 18.7%
2nd	Rural – 20%	Rural - 20%	Urban – 35%	Rural (0.43)	Motorway - 4,6%
3rd	Motorway – 5%	Motorway – 10%	Motorway – 10%	Motorway (0.06)	Urban – 1.4%
[1] (death per million vehicles/km) [2] (percentage of lethal accidents in the total number of accidents)					

Figure 3 – Average distribution of accident in European roads

To have a more precise description of accidents, the SAFESPOT project has performed a detailed road accidents data analysis based on data from different European countries, regions or cities were the expected details were available. We gathered data from Italy and the city of Turin, from French motorways and rural roads of the Brittany province, from urban areas in Germany, and from the Netherlands. Also, we used some specific studies about road departure [6] or intersections accidents [2]. Those data provide different accidents characteristics, like their seriousness, their sources, their locations, the types of vehicles involved, the traffic or weather status, the vehicles' trajectories and the possible rule violations. The different driving environments are described and studied separately as they have specific configuration, traffic flows and accident records.

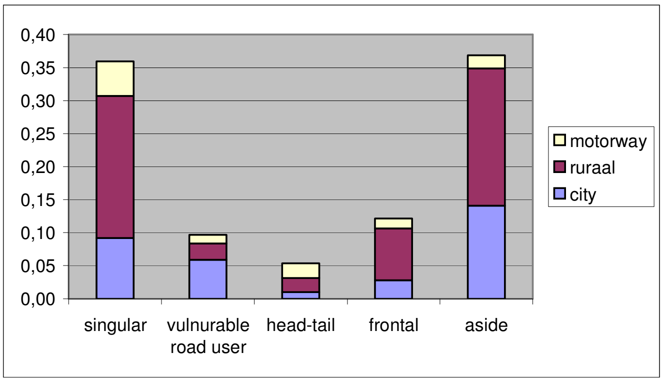

Figure 4 - Kind of accidents by areas, Netherlands, 2000

As an example, it is highlighted that an excessive speed and the lack of attention of the drivers are observed as the main causes, in a high number of accidents, and are often combined together and with other factors. But they did not impact the three different parts of the road network in the same way. The excessive speed is a much more important problem in rural roads and motorways, where it takes place in 40 percent of lethal accident, than in the rural areas, roughly 10 percent. Also, the lack of attention is particularly critical in the urban areas because of the complexity of the road network and the high number of vehicles, pedestrians or motorcycles [4]. On motorways, this is mainly due to the duration of the journeys and the monotony of the roads [5]. The kind of accident is also considered; it gives relevant information on the trajectories and the entities involved as shown in the figure 4.

To ease the use of these data, they were first summarized in “Safety critical scenarios”, as shown in figure 5. Then, the main use cases of the SAFESPOT system were defined around those safety critical scenarios. This was the first picture of the SAFESPOT infrastructure-based applications.

Name	Speed and dangerous driving	
Type	Wrong speed, dangerous driving	42%
Aggravating factor	Speed	
Location	Highway	
Extension 1		
Type	excessive speed	19%
Extension 2		
Type	overtaking, driving to close	12%
Extension 3		
Type	wrong speed with traffic condition	5,9%
Extension 4		
Type	wrong speed with weather condition	3,4%
Extension 4		
Type	insufficient safety distance	1,7%

Figure 5 – Safety critical scenario “Speed and dangerous driving” for Highways

The second objective of this study is to evaluate the possible impact of the applications in terms of reduction of the number of accidents. Each application of the system is related to corresponding accident data in terms of number of collisions, deaths or injuries, taking place in the European road network. Their possible impacts are then discussed and their implementation priority explained.

FROM USE CASE EXAMPLE TO APPLICATION DESIGN

SAFESPOT has now a number of use cases where the system could be applied. Having detailed these use cases, we are defining five main infrastructure-based applications (e.g. were the decision is taken on the infrastructure side) that will be deployed in the next steps of SAFESPOT: “Speed alert”, “Hazard and incident warning”, “Road departure prevention”, “Intersection collision avoidance” and “Safety margin for assistance and emergency vehicles”. In parallel, applications based on vehicles decision were designed in another subproject. We briefly present two applications based on the conclusions of the accident data analysis.

“Speed Alert”: this application provides recommended speeds to drivers on the basis of a real-time evaluation of parameters such as: the weather status, road surface conditions, topology of the road, traffic flow speed and any events (road works, accidents, traffic jam, presence of pedestrians, deviations, etc.). For instance, if a vehicle arrives on a road section that is subject to a traffic jam, the system will warn the driver if he does not slow down early enough. This application is justified as it is a significant cause in more than 40% of accidents in rural roads and motorways. It is also clear that an infrastructure system gives more consistent recommendations than the sole interaction between vehicles by having an extended ‘vision’.

“Intersection Collision Avoidance”: the accident data analysis has highlighted the need of specific applications to enhance safety in rural and urban intersections as 30% of death and 40% of injuries occurred on crossroads or intersections in the Italian rural network [3]. This application typically concerns a static black-spot and deeply exploits real-time computation and communication through high-speed local networks. However, infrastructure support will broadcast information to drivers not only in specific points, but also in wider areas beyond the black-spot. This system also considers cars, pedestrians and other vulnerable road users that are not specifically equipped but need to receive information from the infrastructure traffic signs and panels. The accident data analysis has lead to extend this application, which was first focussing only on urban area, to rural intersections and crossroads.

POTENTIAL IMPACT

To validate the design of the SAFESPOT infrastructure-based applications, the study of their potential impact and a classification of their implementation priority were done. As the SAFESPOT system is based on an interaction with the driver and do not control the vehicle, it is hard to know what will be the acceptation of the system by the driver when he will receive warnings. Also, the definition of the application is not sufficient to know the level of detection that we will obtain. It depends on the available sensors and the time in which we detect a potential accident. So the study of the potential impact is more a description of the number of accidents concerned by an application or a use case.

Figure 6 shows the analysis of the potential impact of the “Road departure application”.

TEST SITE

The SAFESPOT test sites are going to be located in Italy, France, Spain, Germany, the Netherlands and Sweden. They have been chosen to cover the different driving environments. The “Western Europe Site Test”, WEST, is located in the west of France and in Spain. It comprises a set of different and complementary sections of different types of network: motorways, rural roads, urban roads and test tracks. The German urban test site is located in the city of Dortmund, which is part of the German

Ruhr Area. The Ruhr Area can be regarded as a large conurbation that comprises about 15 larger cities and about 5.400.000 residents. Dortmund as a city of about 600.000 residents is one of the largest cities in the Ruhr Area. The city operates more than 450 intersection traffic light controllers, traffic control centres and several public transport operators. In the Netherlands the Rotterdam-Brabant-Antwerp corridor has been chosen to act as a test site. In this corridor a number of developments are of particular interest to traffic safety and efficiency. The geographical area to be covered in Sweden focuses on the larger cities. A tunnel area will be in Göteborg. The site is concentrating on Vehicle-Vehicle focused applications with infrastructure support. The main development will be done in Göteborg. The Italian test site will be of support for the SAFESPOT activities for the Italian partners of the project. Most of the activities will be located in the Turin area.

Road departure prevention	
Scope:	Accident causes: All causes where a road departure can be the main or an aggravating factor and where the application speed alert is not strongly relevant.
Related Use cases:	- Obstacles : SP5_UC16 - Misjudgement : SP5_UC21 - Rule violation: SP5_UC32 - Critical environment conditions : SP5_UC41, SP5_UC42, SP5_UC45 - Safety improving driver assistance :
Potential impact (The Road Departure application will impact on all the 3 main environments)	
Urban area	Scenario : Driver's lack of vigilance - leaving the carriageway: 20% Supposing a 100% reliable system working on all the cars, then we could expect that the Road Departure application would cover around 20% of the German urban lethal accidents.
Rural area	The French data analysis on rural roads reports that between 30% and 40% of the accidents are of "Run-off road" type. These figures give an idea of the potential impact of a 100% reliable SAFESPOT system working on all the cars and in all the areas.
Motorway	Scenario : Driver's lack of vigilance - Veer of the lane 25% A 100% reliable SAFESPOT system should be able to manage about 25% of road departure accidents in Italian and French motorways.

Figure 6 – Potential impact analysis for the road departure prevention application

CONCLUSIONS

Following the recommendation of the European Commission, the analysis of accident data has proven its efficiency in giving an enhanced knowledge on the main safety problems that drivers may face while using European roads. Furthermore, it has improved the design of the SAFESPOT applications based on the cooperation of the infrastructure equipment. Also, the study of their potential impact has strengthened the confidence of the different partners of the project in the objectives of the applications. The major problem of this task was to overtake the differences of data coming from various European countries. Indeed, the improvement of the CARE and EACS databases, or the progress of the SAFETYNET, RANKERS or PENDANT projects will certainly be of great help for engineers focussing on safety applications on European roads.

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