The SAFESPOT Integrated Project: an overview

G. Vivo (CRF-Centro Ricerche FIAT, Italy)

Abstract— **The SAFESPOT European Integrated Project is co-funded by the European Commission Information Society Technologies and started its activities on the design and development of cooperative systems for road safety in February 2006. The project, promoted by EUCAR (the research association of the Car Manufacturers), will last four years, it is coordinated by Centro Ricerche Fiat, it includes 51 partners from 12 different European countries (Italy, Germany, France, UK, Spain, Sweden, the Netherlands, Finland, Belgium, Greece, Poland, Hungary) among car makers, suppliers, road operators, service providers and research centres.**

The main aim of the project is to understand and assess, through tests in real conditions, the potential of a cooperative approach in terms of road transport safety improvement.

This paper is an overall description of the project aims and objectives and reports the basic results of the first phase of the SAFESPOT project activities, namely the definition of the relevant use cases , scenarios of applications and requirements.

I.INTRODUCTION

ROAD safety is a major issue affecting society.

The reduction of fatalities is currently supported by passive and active safety systems that sensibly decrease the probability of an accident to occur and mitigate the consequences of accidents on vehicle occupants and other road users.

Furthermore, in the past decade a lot of research has been dedicated to improve safety by the development of driver assistance systems based on autonomous sensor technologies that are able to perceive the traffic situation surrounding the vehicle and, in case of danger, to properly warn the driver or to take control of the vehicle.

Sensor technologies essentially based on radar and video sensing, enables the possibility to have in real time a picture of the vehicle surroundings, thus improving road safety by avoiding an important number of accidents, or at least reducing their effects. The research and development in this field allowed a deep understanding of the advantages and disadvantages of such systems and some of them are already hosted or close to become hosted in our vehicles at a reasonable cost.

In parallel the wireless technologies made formidable progresses.

All these achievements are a sound basis for a breakthrough in accident prevention with a new approach: a cooperative network where the vehicles and the infrastructure equipments are part of a unique system sharing information gathered on-board and at road-side in order to enhance the driver perception of the vehicle surroundings and consequently the road safety.

With a radio link you can "see" beyond a curve, a stopped car in the middle of the road or your car can immediately warn all the following vehicles when you start an emergency brake. An infrastructure controller running an incident detection application based on cameras or other sensors' information is able to immediately diffuse the information of a detected accident to all the incoming vehicles or to suggest the best speed to keep in case of low friction due to ice on the road.

All round the world these concepts and the appeal of cooperation stimulated researchers and all stakeholders (car manufacturers, road operators, public authorities) started seriously to consider this new approach.

European Car makers decided to deal with this subject within the CAR to CAR Communication Consortium (C2C-CC) [2] that has the main objective to define a unified protocol for inter-vehicle communication. The protocol is intended to be used also by road side units that participate in the network as static nodes.

Different car makers and road operators should agree on this protocol in order to ensure that a vehicle, independently of its brand, may correctly inter-operate with other vehicles and infrastructure devices on each equipped road of any country.

This background, the sponsorship of EUCAR (the European Car makers research council) [4] and the cooperation of 51 partners (composed of car makers, road operators, automotive and road equipment suppliers , universities and technical research centres from 12 European countries) gave the life to the SAFESPOT integrated project[1].

SAFESPOT, started in Feb 2006, will end on January 2010 and has an overall budget of about 38 Million of Euros (20.5 of which funded by the European Commission).

The main objectives of SAFESPOT are the following

- To developed or improve and assess the *key enabling technologies*:
  - *Communication* through *ad-hoc dynamic network* whose nodes are vehicles and road side units.
  - *An accurate relative positioning*
  - *Local dynamic maps.*
  - SAFESPOT shall also evaluate how a new generation of wireless network sensors may improve the sensing techniques at infrastructure level.
- To develop the *Safety Margin Assistant*, that is an integrated application framework using the *safety-related information* provided by the network properly fused with the on board sensor and able to advise the driver in order to keep the vehicle as far as possible from emergency situations or to provide a proper warning when they occur
- To define in commonality with other EC projects an open flexible and modular architecture

- To evaluate the impacts and the end-user acceptance. Also, the efficacy and the risks in the initial period, with a reduced percentage of equipped vehicles, must be carefully analyzed.
- To evaluate the liability aspects, regulations and standardisation issues which can affect the implementation. These systems will deeply involve the whole society and a lot of organizational and political issues at regional, national and European level will surely be raised.

II.The Ad hoc communication network.

The core of the SAFESPOT system is the communication system.

SAFESPOT is focused on an Ad Hoc Communication NETwork (AHCNET) operating at local level and integrated in a more general communication framework.

An AHCNET protocol, based on IEEE802.11p, was already specified by C2C-CC and will be properly extended with a more complex addressing mechanism in order to take into account geo-aware addressing and multi –hopping (fig. 1).It is important to underline that for the exploitation of this protocol the allocation of a protected frequency band of 20MHz. in the 5.9 Ghz. range is required. Actions supported by the European Commission are going on to obtain this spectrum allocation at European level.

This protocol will be integrated with the CALM ISO standard [3] aimed at providing a unified layer in order to decouple applications from the specific protocol and media used for the data transmission in mobile applications.

The CVIS integrated project [5], another important project devoted to cooperative applications for mobility efficiency, is committed to implementing the CALM standard.

The overall framework is represented in fig. 2.

III.Accurate relative positioning

For several SAFESPOT applications sub-meter precision is needed.

Standard GPS or even Galileo are not sufficient.

Several approach are possible and different technologies are currently being analyzed.

These are the main solutions under analysis

- Exchange of GPS raw data among vehicles that improves the relative positioning of objects.
- Use of complementary sensors. Particularly interesting is the laser-scanner provided by IBEO (partner of the project) that allows the recognition of landmarks registered on the digital maps.
- Use of Ultra Wide band communication referred to infrastructured stations.

All the different solutions will be evaluated individually and also will be combined with the “Data Fusion” algorithm. The aim of the Data Fusion approach for accurate positioning is to estimate a precise position relative to a digital map and relative to other vehicles. To reach this precise position estimation, the information from different sources are used and combined. The different information sources are the outputs of the different localization tasks/sensors. The principle structure of the modules is shown in fig.3.

IV.Local Dynamic Maps.

The SAFESPOT concept foresees a local dynamic map (LDM) based on a geographical static layer on which more layers are overlapped and populated by the safety relevant elements in order to reconstruct continuously the scenario around a vehicle or in a local area around an infrastructure equipment.

The LDM is a database containing these elements as represented in the following picture.

The location of all elements considers the hosting node (vehicle or RSU) as the reference axis origin.

As illustrated in fig. 4 we have several layers:

- The bottom layer consists of the (quasi) static map from the digital map provider according to the conceptual approach of Geographic Data File (GDF).
- The second layer extends the static map with additional traffic attributes, static road side units and communication node features, intersection features and landmarks for referencing and positioning. These new static data can be seen as GDF extension for cooperative systems.
- The third layer contains temporary regional information like weather, road or traffic conditions. This layer will deal with the dynamic object approach.
- The top layer contains dynamic communication nodes as well as other road users detected by in-vehicle sensors like vision, laser scanner etc. The elements contained in this layer are the result of a process of data fusion operated by each unit (on board or at road side)

V.The SAFESPOT applications

The SAFESPOT Integrated Project is focused on cooperative road safety. The aim is to prevent road accidents by developing a “Safety Margin Assistant” that:

- detects in advance potentially dangerous situations,
- extends “in space and time” drivers’ awareness of the surrounding environment.
- provides recommendations to keep the driver inside a safety margin.to keep the vehicle as far as possible from emergency situations or providing a proper warning when they occur.

The SMA relies on the data available in the LDM where all safety relevant information are continuously updated.

In other words the SMA operates as a smart adviser trying to keep the vehicle as far as possible from emergency situations or providing a proper warning when they occur.

The SMA relies on the data available in the LDM where all safety relevant information are continuously updated.

From a technical viewpoint the SMA may be considered as a frame integrating several applications.

SMA should be able to operate, in perspective, in any road scenario. Critical safety scenarios may be considered as *Black Spots* that are commonly defined as locations where statistics show a higher probability that an accident can occur (intersections, curve) or where the probability that an accident occurs is rather low but when they happen, the consequences can be very severe; also incident management is more complex and difficult and there is generally no alternative road (bridge, tunnel).

We may call these locations *Static Black Spots.* The dangerousness could be always present with a fixed level of risk or may depend on different conditions (period of the year, traffic jams, fog, …).

In this case we may speak of *Quasi-Static Black Spots*.

Furthermore we may consider as *Dynamic Black Spots*, scenarios where a set of conditions occur that may lead to an accident (e.g. an obstacle on the road, a vehicle break-down, a wrong manoeuvre by a driver,…). This kind of Black Spot is not linked to a specific location and consequently may happen anywhere and with higher probability in Static or Quasi-Static Black-Spots.

Static and Quasi-Static black spots are the first addressed implementation areas for the infrastructure sensing for road safety.

SAFESPOT identified two classes of implementation steps depending on the level of intelligence required on board the vehicle.

The first one is mainly based on V2I-I2V and with applications mainly running on the infrastructure side. These applications may represent a first step of the future exploitation and are addressed to cover Static and Quasi-Static - Black Spots and Dynamic Black Spots occurring in those locations.

The second step are V2V based applications that are totally addressed to dynamic black spots in any location and require a higher level of intelligence on board.

Integrating V2V-V2I-I2V communication the maximum level of coverage is possible. SAFESPOT has also the objective to evaluate how the level of intelligence may be distributed between vehicle and infrastructure in order to optimize the benefits.

In the first year of the project several use cases were described and analysed and currently the specification phase is on going.

The considered applications span from simple event warnings to more complex functionality up to a cooperative collision warning or intelligent intersection management.

Table 1 reports the list of addressed applications.

Tab. 1 List of applications.

Application
Road Intersection Safety
Lane Change Manœuvre
Safe Overtaking
Head On Collision Warning
Rear End Collision Warning
Speed Limitation and Safety Distance
Frontal Collision Warning
Road Condition Status – Slippery Road
Curve Warning
Vulnerable Road User Detection and Accident Avoidance
Emergency management

Some examples of applications are described in the following:

Curve warning may be operated providing smart signalling to the driver with different levels of information. The signalling is issued by infra-structure, information may be static or collected by road sensors or by vehicles acting as mobile probes. fig.5(a) represents a simple static warning situation, signalling the presence of a dangerous curve. fig. 5(b) represents a situation in which the first vehicle acts as a probe using its own sensor to detect a critical road condition, and the infrastructure is able to warn new coming vehicles.

In fig. 5(c) represents *a Rear End Collision Warning* use case where the communications is achieved only through direct link among vehicles.

In fig.6 a *Complete Cooperative Collision Warning* scenario is depicted, with a fully equipped vehicle integrating through a "data fusion" all information available from on board sensors and communication from other vehicles or road side units.

Others complex scenarios, very critical from a safety viewpoint, are the road intersections.

The application monitoring road intersections will be analysed with different equipment configurations, starting from a centralised controller to solutions where the vehicles are mainly passive (provide/receive information) to a solution where all the algorithms are running on the vehicles based on an LDM.

The SMA in the intersection scenario is expected to provide the following set of measures and driver assistance services:

- Surveillance of intersections and their surroundings in order to detect dangerous situations at an early stage and to inform vehicles/drivers being affected;
- The safe speed and manoeuvre to approach the intersection is suggested to the driver.
- A warning to the driver is issued: (1) if the driver is not following the rules (for example: he is not stopping), or (2) if there is a risk of accident (for example: another vehicle is infringing the intersection rules);
- Brake and accelerate recommendations at intersection approaches in order to synchronize vehicle behaviour with traffic lights phases;
- Speed recommendations with respect to passing of signalised intersections or green waves;
- A specific infrastructure-based warning system is used to also warn non-equipped vehicles;
- Warnings for turning vehicles with respect to permissive flows, conflicting pedestrians and cyclists;
- In-vehicle display of traffic lights, static and dynamic traffic signs and intersection topology.

VI. The business perspective of cooperative safety

The SAFESPOT IP has the strategic goal to establish a feasible vehicle - infrastructure and vehicle - vehicle infrastructure architecture. A fundamental issue is to prove the architecture feasibility from a business perspective. Due to the particular subject and the complexity involved, the business sustainability has to be proven involving many aspects (organization, legal, responsibilities, regulations, economical) evaluating risks and defining guidelines and suggestions for the different actors, as well as the government.

A specific Subproject of SAFESPOT, named BLADE is focused on all these aspects. The main objective is to "pave the road" from the experiments and tests performed within the SAFESPOT IP to the real life. The sub-project activities are oriented to the deployment of the project results with analysis of potential barriers and identification of suitable steps to reach the goal of the IP, to the analysis of legal aspects which have to be considered for an efficient deployment programme and to the identification of a business model suitable for system, applications and services addressed by the IP.

VII. The test sites

SAFESPOT has planned the preparation of different test sites in six European countries (France, Germany, Italy , Spain, Sweden, The Netherlands).

Highway, rural roads, test tracks, tunnels will be equipped as well as several vehicles.

The target is the test and validation of different applications and technologies in the last year of the project (2009).

The road systems will benefit from integration with pre-existing control systems, pre-installed stations and sensors. In most test sites a close cooperation with CVIS will optimize the possibilities to reuse vehicles and infrastructure facilities.

Different test sites are also a means to demonstrate the interoperability of implemented applications.

VIII. The first year's achievements

First year activities were devoted to defining the system boundaries and requirements, as well as to establish all the needed links with parallel projects.

A total of 28 deliverables were produced. All these deliverables are available on [1] as complete documents or "abstracts" according to confidentiality classifications.

Some important achievements are the following:

- Application requirements and definition of the SMA concept
- General requirements
- Technological and communication requirements
- Architecture based on FRAME project results
- Statement of the use of LDM as the intermediate layer for Applications to access all the safety relevant information
- Use of local AHCNET as unique communication media and interface/integration to a more global system (e.g. CVIS) for applications needing a wider geographical extension.
- Analysis of available sensors (on board and on the road)
- Use cases of different applications
- Report on preliminary analysis and initial deployment programme

IX. Conclusion

SAFESPOT is dealing with an extremely complex system and the objectives are quite challenging.

The first year activities brought a clearer comprehension of criticalities and a first outline of possible solutions. In the next three years all developments and validations should confirm the expected high potentiality of this approach for a dramatic improvement of road safety, paving the road for the actual exploitation in European countries.

References

[1] www.safespot-eu.org.
[2] www.car-to-car.org.
[3] www.ieee802.org/802_tutorials/nov06/
[4] www.eucar.be.
[5] www.cvisproject.org
[6] www.frame-online.net.
[7] www.sevecom.org.
[8] www.comesafety.org.