# Technological Implementation Plan

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<th>D8.2.4</th>
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## Revision Log

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<tbody>
<tr>
<td>ADAS</td>
<td>Advanced Driver Assistance System</td>
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<tr>
<td>ARTIST</td>
<td>Architettura Telematica Italiana per il Sistema dei Trasporti (Italian Telematics Architecture for the Transport System)</td>
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<tr>
<td>AUTOSAR</td>
<td>Automotive Open System Architecture</td>
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<td>C2C-CC</td>
<td>Car to Car Communication Consortium</td>
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<td>C2X</td>
<td>Car to Car and Car to Infrastructure</td>
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<tr>
<td>CAM</td>
<td>Cooperative Awareness Message</td>
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<td>CAN</td>
<td>Controller Area Network</td>
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<td>CCTV</td>
<td>Closed Circuit Television</td>
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<td>DAQ</td>
<td>Data Acquisition Module</td>
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<td>DFL</td>
<td>Data Fusion Logic</td>
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<tr>
<td>DR</td>
<td>Detection Rate</td>
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<tr>
<td>DSRC</td>
<td>Dedicated Short Range Communication</td>
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<tr>
<td>E/E</td>
<td>Electric and Electronic</td>
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<tr>
<td>ECC</td>
<td>Electronic Communications Committee</td>
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<td>ECAID</td>
<td>Extended Cooperative Automatic Incident Detection</td>
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<tr>
<td>ECU</td>
<td>Electronic Control Unit</td>
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<tr>
<td>EMC</td>
<td>Electromagnetic Compatibility</td>
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<tr>
<td>ERM</td>
<td>ETSI Committee on EMC and Radio Spectrum Matters</td>
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<tr>
<td>ESPOSYTOR</td>
<td>SAFESPO SYSTEM MONITOR</td>
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<tr>
<td>ETHERNET</td>
<td>One type of network technology for local area networks</td>
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<td>ETSI</td>
<td>European Telecommunications Standards Institute</td>
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<td>EV</td>
<td>Ego Vehicle</td>
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<td>FAR</td>
<td>False Alarm Rate</td>
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<td>FM</td>
<td>Frequency Management</td>
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<td>FOT</td>
<td>Field Operational Test</td>
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<td>GPRS</td>
<td>General Packet Radio Service</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>H&amp;IW</td>
<td>Hazard and Incident Warning</td>
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<td>HMI</td>
<td>Human Machine Interface</td>
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<td>HUD</td>
<td>Head Up Display</td>
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<td>HW</td>
<td>Hardware</td>
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<td>I2V</td>
<td>Infrastructure to Vehicle</td>
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<tr>
<td>IC</td>
<td>Integrated Circuit</td>
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<tr>
<td>IEEE</td>
<td>Institute of Electrical &amp; Electronics Engineers</td>
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<tr>
<td>IP</td>
<td>Integrated Project</td>
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<tr>
<td>IRIS</td>
<td>Intelligent Cooperative Intersection Safety</td>
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<tr>
<td>ITS</td>
<td>Intelligent Transport Systems</td>
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<tr>
<td>LCD</td>
<td>Liquid Crystal Display</td>
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<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>LCM</td>
<td>Lane Change Manoeuvre</td>
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<td>LDM</td>
<td>Local Dynamic Map</td>
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<tr>
<td>LED</td>
<td>Light-emitting diode</td>
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<td>LIDAR</td>
<td>Light Detection and Ranging</td>
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<td>MP</td>
<td>Mass Production</td>
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<tr>
<td>OBD</td>
<td>On Board Diagnostics</td>
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<tr>
<td>OBU</td>
<td>On Board Unit</td>
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<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<tr>
<td>OV</td>
<td>Other Vehicle</td>
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<tr>
<td>PC</td>
<td>Personal Computer</td>
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<tr>
<td>PDA</td>
<td>Personal Digital Assistant</td>
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<tr>
<td>PTW</td>
<td>Powered Two Wheelers</td>
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<td>RDEP</td>
<td>Road Departure Prevention</td>
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<tr>
<td>RF</td>
<td>Radio Frequency</td>
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<td>SLSD</td>
<td>Speed Limitation and Safety Distance</td>
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<td>RADAR</td>
<td>Radio Detection and Ranging</td>
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<td>RSU</td>
<td>Road Side Unit</td>
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<td>SDM</td>
<td>Safe Drive Map</td>
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<td>SIM-TD</td>
<td>Safe Intelligent Mobility – Test Area Germany</td>
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<td>SLSD</td>
<td>Speed Limitation and Safety Distance</td>
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<td>SMA</td>
<td>Safety Margin Assistant</td>
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<td>SO</td>
<td>Safe Overtaking</td>
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<tr>
<td>SOAP</td>
<td>Simple Object Access Protocol</td>
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<td>SP</td>
<td>Sub Project</td>
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<td>SPA</td>
<td>Speed Alert</td>
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<tr>
<td>SW</td>
<td>Software</td>
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<tr>
<td>TFT</td>
<td>Thin Film Transistor</td>
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<tr>
<td>TTCN</td>
<td>Testing and Test Control Notation</td>
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<tr>
<td>TTD</td>
<td>Time To Detect</td>
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<tr>
<td>TV</td>
<td>Television</td>
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<tr>
<td>UDP</td>
<td>User Datagram Protocol</td>
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<tr>
<td>VANET</td>
<td>Vehicle Ad-hoc Network</td>
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<tr>
<td>V2I</td>
<td>Vehicle to Infrastructure</td>
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<td>V2V</td>
<td>Vehicle to Vehicle</td>
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<tr>
<td>VMS</td>
<td>Variable Message Sign</td>
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<tr>
<td>WG</td>
<td>Working Group</td>
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<td>WAVE</td>
<td>Wireless Access in Vehicular Environments</td>
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<td>WLAN</td>
<td>Wireless Local Area Network</td>
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<td>WSN</td>
<td>Wireless Sensor Network</td>
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EXECUTIVE SUMMARY

The present SAFESPOT integrated project deliverable entitled: “Technological Implementation Plan” has been prepared to give an overview of the results achieved in the project and of its perspectives towards future implementation in real products. All results are listed and described considering their impact and possible applications.

The purpose of the implementation plan is to describe how the main results of the SAFESPOT project will or can be exploited, by project partners or eventually by other parties.

It provides informative elements about the strategies and the measures to be followed by the SAFESPOT project consortium members in order to raise awareness of Cooperative Systems within the professional community as well as with the general public.

The exploitation plan document is organised as follows.

In the body of the document an overview of the project and its main results is provided, to indicate in which domains and to what timelines the SAFESPOT results are expected to be exploited.

This section of the document is public.

In the annex part of the document, the detailed descriptions of all exploitable results and envisioned exploitation plans, including contact details of main contact people for each result, are given.

This section of the document is restricted.
1. Introduction

The SAFESPOT project is an Integrated Project (IP) within the EU’s 6th Framework R&D Programme running from 1st February 2006 to 31st July 2010. The main objective of SAFESPOT is the definition of the “Safety Margin” and the development of systems which implement it, in order to allow the driver to evaluate correctly the traffic conditions and to adopt a safe behaviour. This achievement is based on the cooperative approach, where road vehicles communicate with other vehicles and with equipped nearby roadside infrastructure.

1.1. Scope of the SAFESPOT project

The key to avoid road accidents is to extend drivers’ time/space horizon in their perception of safety-relevant information, and to improve the precision, reliability and quality of this information.

The extent of ‘perception’ of autonomous vehicle-based systems cannot obviously go beyond the operative range of the sensors. Although effective real time awareness of the vehicle’s “surrounding environment” can be achieved, this clearly has limits. Extended coverage is possible only through collaboration between the infrastructure’s and the vehicles’ sensing abilities. By combining data from roadside sensors and data made available by vehicles in the vicinity, advance knowledge can be gained of potential safety risks, e.g. an icy patch, fog bank, obstacle or accident on the road ahead (but out of sight). The communication of warnings and advice to approaching vehicles (both directly to onboard units and via roadside signals) will provide the extra reaction time necessary to prevent an accident occurring.

One of the main aims of SAFESPOT is to develop a “Safety Margin Assistant” which will extend in space and time the safety information available to drivers by:

- using both the infrastructure and vehicles as sources (and destinations) of safety-related information, and definition of an open, flexible and modular communications architecture;
- developing the key enabling technologies: accurate relative positioning, ad-hoc dynamic networking, local dynamic maps;
- developing a new generation of infrastructure-based sensing techniques;
- testing scenario-based applications to evaluate the impacts and end-user acceptability;
- defining the practical implementation of such systems, especially in the interim period when not all vehicles will be equipped;
- evaluating the liability aspects, regulations and standardisation issues which can affect implementation: involvement of public authorities from the early stages will be a key factor for future deployment.
1.2. Overall planning for the technological implementation

The main technological targets of the SAFESPOT project deal with the feasibility and benefits of co-operative systems solutions in improving road safety well beyond the level which can be achieved with other solutions (vehicle or infrastructure based).

In order to develop co-operative systems with the needed characteristics, and with the precision, reliability and speed required by safety applications, specific technological results have been achieved.

In the project activities these achievements have been defined, developed at the prototype level and validated on test sites which reproduce nearly real-life conditions. The main technologies that SAFESPOT analyzed and developed are the following:

a) A solution for the relative, accurate positioning between vehicles; currently available GPS localisation systems and devices are not precise enough for safety applications, where a precision in the order of few tenths of centimetres is often required. It is relevant to underline that it is not always strictly necessary to know the position on an absolute grid, but only the one that is relative to the other vehicles or infrastructure nodes. Specific solutions, based on the co-operation between vehicles and infrastructure, have been investigated, developed and tested.

b) The local dynamic maps; the road geometry, from highly accurate digital maps, has been integrated with the multi layered information of a dynamic nature collected by the infrastructure or the vehicles (road status, obstacle presence, etc.).

c) Common awareness, exchange of information and multi hop routing in an ad-hoc network of vehicles and infrastructure nodes; specific routing and communication strategies have been defined and developed to take into account the constraints and the specific aspects that should be adopted to sustain the cooperative approach.

In addition, relevant results obtained in the SAFESPOT project consisted in the design and development of vehicle-to-vehicle and vehicle-to-infrastructure applications whose benefits have been demonstrated, in the test site subprojects, for a large number of accident types with a calculated potential safety impact (in terms of saving life as well as other gains).

For some accident types, the benefits are related to their consequences, for example accidents due to driver illness could not be avoided (without a specific vehicle control, beyond the scope of the project), but SAFESPOT will reduce the effect on other road users. These specific achievements have been assessed by two indicators: the percentage of accidents that could be avoided by using the proposed systems, and the demonstration of the feasibility of achieving the reduction. The social benefits have been addressed during the definition of the deployment strategies and business model definition. See [15] “SAFESPOT Deployment Programme” for a deepening on the matter.

The definition of the business model, which is a key element for the co-operative approach, has been a relevant project objective on its own: a large number of stakeholders have been involved (car manufacturers, suppliers, road operators,
public authorities, governments, etc.) and the benefits for some of them are not as direct as in other types of business. End Users - the driver/owner of a vehicle - will need to be convinced of the widespread and immediate usefulness of the systems (not only at some future time when co-operative systems will be fully exploited and penetrated in the markets).

An additional non technical result has been the development of a solution for the vehicle and infrastructure platform that will survive over time, allowing the introduction of new technologies, new types of sensor, and new applications as they emerge. Furthermore, this solution has to be workable with a mix of new and old vehicles, new and old infrastructure, and, last but not least, in the whole of Europe.

A further very important achievement consisted in showing that the safety impact can be implemented without affecting transport efficiency. In the SAFESPOT scenarios, the driver will still be responsible for the vehicle, but will be supported with appropriate suggestions in terms of speed, headway, etc., in a particular traffic context and road conditions. The driver will be free not to adopt the advice under his/her responsibility. However, if a dangerous situation occurs, this will be tracked and appropriate information support will be given to protect other road users. Today, the consequence of an unsafe driver is often an accident which may well involve other (innocent) road users.

In the present Technological Implementation Plan, a total of 41 exploitable results are described, as major outcome concerning the SAFESPOT development and implementation of:

- HW and SW packages;
- Applications;
- Methodologies produced in the project.

The following figure summarises the overall results of the technological implementation, showing the SAFESPOT architecture where all the exploitable results are identified. The reference of the companies that are the main contact point for the individual results are also included.
Figure 1. Overall results of the technological implementation, in relationship with the SAFESPOT architecture
## 2. Summary of the SAFESPOT project key results

### Table 1. List of SAFESPOT Integrated Project results

<table>
<thead>
<tr>
<th>No.</th>
<th>Self-descriptive title of the result</th>
<th>Category A, B or C*</th>
<th>Partner(s) exploiting the result, year of deployment on the market</th>
<th>Contact Person Name, Company, Email</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Relative positioning (SP3)</td>
<td>A</td>
<td>CRF, TUC, DLR 2016</td>
<td>Carlo Liberto Centro Ricerche FIAT S.c.p.A. <a href="mailto:carlo.liberto@crf.it">carlo.liberto@crf.it</a></td>
</tr>
<tr>
<td>2</td>
<td>VANET (SP3)</td>
<td>A</td>
<td>CRF, DAI 2015</td>
<td>Giuliana Zennaro Centro Ricerche FIAT S.c.p.A. <a href="mailto:giuliana.zennaro@crf.it">giuliana.zennaro@crf.it</a></td>
</tr>
<tr>
<td>3</td>
<td>Local Dynamic Maps (SP3)</td>
<td>A</td>
<td>Teleatlas, Navteq 2015</td>
<td>Oliver Kannenberg Teleatlas <a href="mailto:oliver.kannenberg@teleatlas.com">oliver.kannenberg@teleatlas.com</a></td>
</tr>
<tr>
<td>4</td>
<td>In-vehicle SAFEPROBE platform (SP1)</td>
<td>A</td>
<td>Bosch 2016</td>
<td>Sheung Ying Yuen-Wille Bosch GmbH <a href="mailto:sheungying.yuen@de.bosch.com">sheungying.yuen@de.bosch.com</a></td>
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<td>5</td>
<td>Data Acquisition Module (SP1)</td>
<td>A</td>
<td>Continental Automotive 2014</td>
<td>Hongjun Pu Continental Automotive GmbH <a href="mailto:hongjun.pu@continental-corporation.com">hongjun.pu@continental-corporation.com</a></td>
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<td>6</td>
<td>Situation refinement (SP1)</td>
<td>A</td>
<td>ICCS 2015</td>
<td>Angelos Amditis Institute of Communication and Computer Systems (ICCS) <a href="mailto:a.amditis@iccs.gr">a.amditis@iccs.gr</a></td>
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<tr>
<td>7</td>
<td>Object refinement (SP1)</td>
<td>A</td>
<td>CRF 2015</td>
<td>Andrea Saroldi Centro Ricerche FIAT S.c.p.A. <a href="mailto:andrea.saroldi@crf.it">andrea.saroldi@crf.it</a></td>
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<td>8</td>
<td>Laserscanner system for vehicles (SP1)</td>
<td>A</td>
<td>Ibeo 2015</td>
<td>Florian Ahlers Ibeo Automobile Sensor GmbH <a href="mailto:florian.ahlers@ibeo-as.com">florian.ahlers@ibeo-as.com</a></td>
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<td>9</td>
<td>Road state monitoring camera (SP2)</td>
<td>A</td>
<td>VTT 2014</td>
<td>Matti Kutila VTT Technical Research Centre of Finland <a href="mailto:matti.kutila@vtt.fi">matti.kutila@vtt.fi</a></td>
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<td>No.</td>
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</tbody>
</table>
| 10  | Thermal imaging for pedestrian/animal detection (SP2) | A | VTT 2014 | Johan Scholliers  
VTT Technical Research Centre of Finland  
johan.scholliers@vtt.fi |
MIZAR  
angela.spence@torino.miz.it |
| 12  | WSN for Intelligent Transportation Systems (SP2) | A | ISMB 2014 | Giuseppe Franco  
ISMB  
giuseppe.franco@ismb.it |
| 13  | CCTV camera for environmental conditions detection (fog, rain, …) (SP2) | A | LCPC 2011-2013 Industrial project to develop and test the product. 2014 Deployment on the market | Nicolas Hautière  
Laboratoire Central des Ponts et Chaussées (LCPC)  
nicolas.hautiere@lcpc.fr |
| 14  | Data Fusion Logic for RSU (SP2) | A | TUM, MAT.TRAFFIC 2014 | Tobias Schendzielorz  
Technische Universität München, Chair of Traffic Engineering and Control  
tobias.schendzielorz@vt.bv.tum.de |
| 15  | Laserscanner system for infrastructure (SP2) | A | IBEO 2014 | Florian Ahlers  
Ibeo Automobile Sensor GmbH  
florian.ahlers@ibeo-as.com |

**APPLICATIONS**

<table>
<thead>
<tr>
<th>No.</th>
<th>Self-descriptive title of the result</th>
<th>Category A, B or C</th>
<th>Partner(s) exploiting the result, year of deployment on the market</th>
<th>Contact Person Name, Company, Email</th>
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</table>
| 16  | Extended Cooperative Automatic Incident Detection - ECAID (SP2) | A | CSST 2013 | Morello Eugenio  
Centro Studi sui Sistemi di Trasporto SpA - CSST  
eugenio.morello@csst.it |
| 17  | Safety Margin Assistant – application framework and HMI (SP4) | A | CRF 2016 | Giulio Vivo  
Centro Ricerche FIAT S.c.p.A.  
giulio.vivo@crf.it |
| 18  | External Message Application (SP4) | A | CRF 2016 | Giulio Vivo  
Centro Ricerche FIAT S.c.p.A.  
giulio.vivo@crf.it |
<table>
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<th>No.</th>
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<tbody>
<tr>
<td>19</td>
<td>Road Intersection Safety (SP4)</td>
<td>A</td>
<td>CAS, Renault 2016</td>
<td>Ulrich Stählin Continental Teves AG &amp; Co. oHG <a href="mailto:ulrich.staehlin@continental-corporation.com">ulrich.staehlin@continental-corporation.com</a></td>
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<td>20</td>
<td>Lane Change Manoeuvre (SP4)</td>
<td>A</td>
<td>Piaggio 2016</td>
<td>Paolo Cravini Piaggio &amp; C. S.p.a. <a href="mailto:paolo.cravini@piaggio.com">paolo.cravini@piaggio.com</a></td>
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<tr>
<td>21</td>
<td>Safe Overtaking (SP4)</td>
<td>A</td>
<td>Piaggio 2015</td>
<td>Paolo Cravini Piaggio &amp; C. S.p.a. <a href="mailto:paolo.cravini@piaggio.com">paolo.cravini@piaggio.com</a></td>
</tr>
<tr>
<td>22</td>
<td>Head On Collision Warning (SP4)</td>
<td>A</td>
<td>CRF 2016</td>
<td>Giulio Vivo Centro Ricerche FIAT S.c.p.A. <a href="mailto:giulio.vivo@crf.it">giulio.vivo@crf.it</a></td>
</tr>
<tr>
<td>23</td>
<td>Rear End Collision (SP4)</td>
<td>A</td>
<td>CRF 2016</td>
<td>Giulio Vivo Centro Ricerche FIAT S.c.p.A. <a href="mailto:giulio.vivo@crf.it">giulio.vivo@crf.it</a></td>
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<tr>
<td>24</td>
<td>Speed Limitation and Safety Distance (SP4)</td>
<td>A</td>
<td>MMSE 2015</td>
<td>Piero Mortara Magneti Marelli S.p.A. <a href="mailto:piero.mortara@magnetimarelli.com">piero.mortara@magnetimarelli.com</a></td>
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<td>25</td>
<td>Frontal Collision Warning (SP4)</td>
<td>A</td>
<td>VOLVO 2015</td>
<td>Erik Nordin Volvo Technology Corporation <a href="mailto:erik.nordin@volvo.com">erik.nordin@volvo.com</a></td>
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<tr>
<td>26</td>
<td>Road Condition Status – Slippery Road (SP4)</td>
<td>A</td>
<td>VOLVO 2015</td>
<td>Erik Nordin Volvo Technology Corporation <a href="mailto:erik.nordin@volvo.com">erik.nordin@volvo.com</a></td>
</tr>
<tr>
<td>27</td>
<td>Curve Warning (SP4)</td>
<td>A</td>
<td>CRF 2015</td>
<td>Giulio Vivo Centro Ricerche FIAT S.c.p.A. <a href="mailto:giulio.vivo@crf.it">giulio.vivo@crf.it</a></td>
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<tr>
<td>28</td>
<td>Vulnerable Road User Detection and Accident Avoidance (SP4)</td>
<td>A</td>
<td>VOLVO 2014</td>
<td>Erik Nordin Volvo Technology Corporation <a href="mailto:erik.nordin@volvo.com">erik.nordin@volvo.com</a></td>
</tr>
<tr>
<td>29</td>
<td>Speed Alert - Critical speed warning - legal (SP5)</td>
<td>A</td>
<td>LCPC, COFIROUTE 2015</td>
<td>Sébastien Glaser LCPC <a href="mailto:glaser@lcpc.fr">glaser@lcpc.fr</a></td>
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<td>No.</td>
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<td>30</td>
<td>Speed Alert - Critical speed warning - dynamic (SP5)</td>
<td>A</td>
<td>LCPC, COFIROUTE 2015</td>
<td>Sébastien Glaser LCPC <a href="mailto:glaser@lcpc.fr">glaser@lcpc.fr</a></td>
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<td>31</td>
<td>Hazard and Incident Warning – Obstacle on the road (SP5)</td>
<td>A</td>
<td>COFIROUTE 2015</td>
<td>Fahim BELARBI COFIROUTE <a href="mailto:fahim.belarbi@cofiroute.fr">fahim.belarbi@cofiroute.fr</a></td>
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<tr>
<td>32</td>
<td>Hazard and Incident Warning – Wrong Way Driving (SP5)</td>
<td>A</td>
<td>MIZAR, COFIROUTE 2015</td>
<td>Angela Spence MIZAR <a href="mailto:angela.spence@torino.miz.it">angela.spence@torino.miz.it</a></td>
</tr>
<tr>
<td>33</td>
<td>Intelligent Cooperative Intersection Safety - IRIS (SP5)</td>
<td>A</td>
<td>TUM; MAT.TRAFFIC, PEEK 2015</td>
<td>Tobias Schendzielorz Technische Universität München, Chair of Traffic Engineering and Control <a href="mailto:tobias.schendzielorz@vt.bv.tum.de">tobias.schendzielorz@vt.bv.tum.de</a></td>
</tr>
<tr>
<td>34</td>
<td>Road Departure Prevention (SP5)</td>
<td>A</td>
<td>DIBE 2015</td>
<td>Andre Possani University of Genoa, DIBE <a href="mailto:possani@elios.unige.it">possani@elios.unige.it</a></td>
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<tr>
<td>35</td>
<td>Safety Margin for Assistance and Emergency Vehicles</td>
<td>A</td>
<td>SODIT, CRF 2015</td>
<td>Nicolas ETIENNE SODIT <a href="mailto:etienne@sodit.eu">etienne@sodit.eu</a></td>
</tr>
<tr>
<td>36</td>
<td>Vehicle client application for IRIS (SP4)</td>
<td>A</td>
<td>CA 2015</td>
<td>Hongjun Pu Continental Automotive GmbH <a href="mailto:hongjun.pu@continental-corporation.com">hongjun.pu@continental-corporation.com</a></td>
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**METHODOLOGIES/CONTRIBUTIONS TO STANDARDISATION**

<table>
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<tr>
<th>No.</th>
<th>Self-descriptive title of the result</th>
<th>Category A, B or C*</th>
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<tr>
<td>37</td>
<td>SAFESPOT deployment programme</td>
<td>A</td>
<td>TNO, All 2010</td>
<td>Han Zwijnenberg Technical director TNO <a href="mailto:han.zwijnenberg@tno.nl">han.zwijnenberg@tno.nl</a></td>
</tr>
<tr>
<td>38</td>
<td>SAFESPOT Certification Reference Framework</td>
<td>A</td>
<td>Renault, AT4 wireless, All 2010</td>
<td>Abdel Kader Mokaddem RENAULT <a href="mailto:abdelkader.mokaddem@renault.com">abdelkader.mokaddem@renault.com</a></td>
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<td>SAFESPOT Contribution to the European Harmonised Cooperative Architecture</td>
<td>A</td>
<td>CRF, Renault, DAI, VOLVO 2010</td>
<td>Roberto Brignolo Product Research Centro Ricerche FIAT S.c.p.A. <a href="mailto:roberto.brignolo@crf.it">roberto.brignolo@crf.it</a></td>
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<td>SAFESPOT Conformance Test System (SP7)</td>
<td>A</td>
<td>AT4 wireless 2010</td>
<td>Antonio Plaza Ortega AT4 wireless S.A. <a href="mailto:aplaza@at4wireless.com">aplaza@at4wireless.com</a></td>
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<td>41</td>
<td>SAFESPOT Organisational Architecture (SP6)</td>
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<td>CSST, All 2014</td>
<td>Morello Eugenio Centro Studi sui Sistemi di Trasporto SpA - CSST <a href="mailto:eugenio.morello@csst.it">eugenio.morello@csst.it</a></td>
</tr>
</tbody>
</table>

* A: results usable outside the consortium / B: results usable within the consortium / C: non usable results

The exploitation of each result is inserted in a framework of cooperation that involves a number of stakeholders. Therefore the effective start up of the exploitation phase do not depend only the partners that are indicated as result responsible, at least in most of the cases.
Result #1 – Relative Positioning (SP3)

2.1.1. Overview and perspectives

Relative Positioning between SAFESPOT vehicles is a technology developed in SP3 by TUC, CRF and DLR in collaboration with other partners involved in the Positioning task.

Relative positioning is the calculation of highly accurate baseline vectors between vehicles using common satellite pseudo range measurements, i.e. satellite raw data (see Figure 2. Common pseudoranges and baseline calculation for illustration).

![Figure 2. Common pseudoranges and baseline calculation](image)

By means of the accurate base line vector, the position accuracy of a SAFESPOT vehicle with an enhanced positioning system (red car in Figure 3. ) may be transferred to a vehicle with higher positioning uncertainty (green car).

![Figure 3. Two SAFESPOT vehicles with different position estimate uncertainties](image)

In combining the remote estimate of the red car with the high accurate relative positioning vector, less equipped vehicles profit from better equipped ones.

![Figure 4. The red car transferred its position to the green one using the highly accurate base line vector of the relative positioning](image)
2.1. Result #2 – VANET (SP3)

2.2.1. Overview and perspectives

The VANET router software is a software jointly built between the SAFESPOT and CVIS consortia; it was designed by CRF and developed with the contribution of DAI, Create-net, CNRS and other project partners. It is available at the open source level, and it constitutes the technological platform for the V2I and V2V communication. Each VANET node periodically sends the beacon or CAM message (Cooperative Awareness Message), which is the basic element the inter-vehicular communication. Indeed by means of this message it is possible to have an instantaneous snapshot of the network in the ego-vehicle surroundings and therefore to build the Neighbour Table, that is the list of all the nodes reachable with a single-hop message. Moreover each CAM message contents few selected information, as pseudonymous, position, time reference and speed, in order to provide element for the situation refinement module. The choice of these contents has been mainly defined in cooperation with the applicative needs.

![Figure 5. Usage of CAM/Beacon messages](image)

In the SAFESPOT router it is implemented the main peculiarity of a vehicular network, that is the possibility to address a message to a geographic area and to reach it through multi-hop routing where the forwarder node is chosen on the basis of stochastic criteria. The forwarding node can have access to the message contents only if they are message addressee, on the contrary they just transparently provide a service to the VANET network.

![Figure 6. Transmission of a geo-addressed message](image)
2.2. Result #3 – Local Dynamic Maps (SP3)

2.3.1. Overview and perspectives

The LDM can be considered as an innovative database which represents and maintain up-to-date relevant information surrounding a node in the SAFESPOT network. Four different conceptual layers are used for the LDM database. The bottom layer is the static map as used today in navigation systems with enhanced geometry and attributes (ADAS specification). The second layer contains static information (mainly attributes) that is not yet contained in the standard map database, but may be in the future, e.g. traffic light information and landmarks for positioning. The third layer consists of temporary and dynamic information, for instance the information related to traffic and weather. The fourth and top layer provides a mapping of highly dynamic information, especially concerning autonomous objects that are able to move (motor vehicles, but also pedestrians, bicycles and animals), dynamic communication nodes (coinciding with certain road users, initially especially motorised ones) and other relevant non-permanent objects, in the vicinity of the vehicle. The dynamic content of the LDM is based on information from the vehicle’s own sensors and on information sensed by other vehicles and the infrastructure, and transmitted via the cooperative communication channels.

Like the second and third layers, the top layer is also related to the static map in the bottom layer that forms the basis representation. Static communication nodes (infrastructure related) are represented in layer 2, and in the future may be represented in layer 1. Layers 2, 3 and 4 are currently represented as look aside tables with pointers to the static map database in layer 1. Other relevant static information may not yet have acquired the status of standard map database content element, and thereby need representation in layer 2. Most of the temporary and all dynamic information that is stored in layers 3 and 4 will by their nature never become part of the static map database. Some relatively long-term temporary information, for instance concerning road works, may in the future be incorporated temporarily in the static map database once incremental update is commercially available.
2.3. Result #4 – In-Vehicle SAFEPROBE Platform (SP1)

2.4.1. Overview and perspectives

The in-vehicle SAFEPROBE platform integrates the components #1-#8 in the list of SAFESPOT IP results.

![SAFEPROBE Platform Diagram](image)

**Figure 8. SAFEPROBE simplified platform architecture**

An example of HW architecture and the interconnection among the different PCs in the vehicles is depicted in the following figure. Specifically this figure corresponds to the CRF demonstrator. The HW architecture of the PTW is much simpler.

![In-vehicle Hardware Architecture](image)

**Figure 9. In-vehicle Hardware Architecture**
2.4. **Result #5 - Data Acquisition Module (SP1)**

2.5.1. **Overview and perspectives**

The DAQ is part of the SP1 Framework (Fig. 10). The DAQ receives data frames according to the SP7 "data format and messages" definition via Ethernet from SAFESPOT devices like VANET Router, Positioning PC and Gateway. The data frames will be converted and aligned into data structures which are defined by subsequent components in the SP1 Framework.

![Diagram for DAQ and enclosing components](image)

*Figure 10. Diagram for DAQ and enclosing components*
2.5. **Result #6 – Situation Refinement (SP1)**

2.6.1. **Overview and perspectives**

One of the basic parts of the in-vehicle platform is the situation refinement module. It was developed by the ICCS team within the framework of the SAFEPROBE subproject. *Situation refinement* represents the estimation of relationships between entities in road environments that may be of the same type or of different types.

In figure 11, the architecture of a node in SAFESPOT is depicted and the situation refinement module is highlighted.

![Figure 11. Situation Refinement inside SAFESPOT architecture](image)

The situation refinement module includes algorithms both for the ego vehicle and for the other vehicles in the road environment. The following components constitute the main part of situation refinement:

- Path prediction
- Maneuver detection
- Object to lane assignment
- Traffic estimation

Situation refinement provides an intermediate additional higher level of input to applications. The SCOVA (SP4) applications inside SAFESPOT take advantage of the output of situation refinement in order to accomplish their functionality.
2.6. Result #7 - Object Refinement (SP1)

2.7.1. Overview and perspectives

Object Refinement is a SW module inside the SAFEPROBE perception platform developed in SAFESPOT. It covers the essential task to combine and fuse data coming from different sources, using different reference systems (local and global), and generated at different times. Temporal and spatial alignment techniques are therefore used to locate all objects in the same spatial and temporal frame before data-fusion is performed and output data are generated for the applications. The techniques that have been developed guarantee reduced processing power and are needed whenever there is the need to combine positions derived from absolute coordinates with relative positions. This is the case when data generated from on-board sensors, such as radar and lidar, are fused with data about other vehicles derived from their absolute position as measured by the positioning system (such as GPS). This task implies motion models for all the objects involved, in order to be able to foresee position and motion of the objects at a given time where data-fusion is performed.

During the development and testing phase inside SAFESPOT, it came clear that specific attention has to be paid to the accuracy on time stamp and on orientation associated to vehicle position, because these values strongly affect the possibility to fuse data generated in relative and absolute coordinate systems. In a similar way, also an accurate synchronization of the clocks generating the time reference on the different vehicles is necessary in order to allow data-fusion of data time-stamped from different vehicles.

As a perspective, the next step that is foreseen on this approach that combines information detected from different vehicles would be the data-fusion of obstacle data as derived from on-board sensors (radar or laser) of different vehicles, so that ideally a complete obstacle map of the all traffic situation could be obtained by data-fusion of obstacles detected by all the vehicles involved in that area. This would require a wider V2V communication bandwidth and higher accuracy on time stamp and orientation, but could allow to "see" with the sensors of the other cars in areas that are blind to the ego-vehicle.
2.7. Result #8 – Laserscanner system for vehicles (SP1)

2.8.1. Overview and perspectives

IBEO has developed a Laserscanner based system for passenger cars and trucks to detect, track and classify road users of any kind. It consists of one or more Laserscanners integrated into the front bumper of the host vehicle and a Laserscanner fusion ECU, processing and fusing the perceived data. The data processing with its input and output data is depicted in Figure 12 below.

![Figure 12. Laserscanner based data fusion and processing](image)

The system is able to detect and differentiate between, passenger cars, trucks, motor cycle and pedestrians in the vicinity of the host vehicle. The average detection range is given in Table 2 below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Detection range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger car</td>
<td>&gt;200m</td>
</tr>
<tr>
<td>Truck/ bus</td>
<td>&gt;200m</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>&gt;100m</td>
</tr>
<tr>
<td>Motor cycle</td>
<td>&gt;200m</td>
</tr>
</tbody>
</table>

The next steps will be dealing with further improvement of the algorithms in terms of robustness, downsizing of the Laserscanner itself and the reduction of production costs.
2.8. Result #9 - Road state monitoring camera (SP2)

2.9.1. Overview and perspectives

Every autumn after the first snow rain the news informs us about many crashes and accidents caused by the slippery weather – winter has caught the drivers by surprise once again. Annually over 3800 fatalities occur on a road that is slippery because of water, ice or snow in Europe (EU-18). To prevent such accidents the proactive road state monitoring device has been developed. This enables proactively warning of driver 30 – 70 m ahead of the black spot which may cause lose vehicle control.

On the other hand, the cooperative traffic where the infrastructure transmits messages to the vehicles is anticipated to be reality on 2015. However, to achieve sufficient coverage of the infrastructure components takes time and money and therefore, affordable systems are needed to emerge rapid deployment and thus, enable cooperative vehicle applications to impact on traffic safety. This enables chance for the invention to prevail the existing systems by offering affordable infrastructure component to monitor road conditions and thus, have a large deployment potentiality.

![Figure 13. The road condition monitoring camera and software in the Swedish test site](image)

The system provides measurement of the road surface, and is able to distinguish whether the asphalt is dry, wet, snowy or icy. The equipment is composed of two cameras, optical bandpass and polarising filters and computing unit for image analysis. The system can be mounted in a vehicle behind of windscreen to monitor slippery road. Alternatively on infrastructure to support the future cooperative traffic safety systems and hence, enable provision of proactive warning message for a driver to adapt speed accordingly. The prototype itself comprises and has been tested with output interfaces: CAN for in vehicle applications and Ethernet for cooperative traffic management systems.

The method employs images acquired via horizontal and vertical polarisation filters. When natural or artificial light is reflected from a reflective icy or wet surface, the intensity of the vertical polarisation decreases more than horizontal one compared to reflection from dry asphalt (see Figure 14). In addition, to the polarisation
methodology, the system also comprises graininess analysis, which has significant role to distinguish whether the road surface is snowy, icy or dry. The system may also predict available friction level according pre-defined look-up table.

Figure 14. Measurement principle of the SAFESPOT camera system
2.9. Result #10 - Thermal imaging for pedestrian/animal detection (SP2)

2.10.1. Overview and perspectives

In the Northern countries, collisions with elk or deer are a major cause of accidents: in 2008 in Finland, there were 1593 accidents with moose, with 4 human fatalities, and 3443 dear accidents\(^1\). The most dangerous time is autumn (September-November) especially after dusk.

VTT Technical Research Centre of Finland has developed in the SAFESPOT project a system for warning vehicle drivers for animals on or near the road based on thermal imaging. The system is based on thermal imaging and additionally is able to detect, classify and track objects warmer than the environment, such as pedestrians and vehicles. The system is part of a co-operative traffic safety system. This is the first infrastructure side system that observes living objects using thermal imaging technology which interfaced to part of a co-operative intelligent traffic safety system. The advantage is that the rather expensive thermal camera is not needed in the vehicle side but the warning can be broadcasted to each vehicle passing the risky situation.

The detection is based on thermal vision that uses image analysis to classify the objects (speed, size, shape). The system is integrated to the sensor fusion module which provides data to the local dynamic maps database that models the driving environment.

![FLIR THERMAL IMAGING USER INTERFACE](image)

**Figure 15. User interface (infrastructure side) of the thermal imaging application for animal and pedestrian detection**

The system has been tested in VTT in Finland and in Italy. Detection and classification of objects is a challenging issue, due to the dependency of the object’s temperature profile on the environment temperature, differences in temperature across the object’s body. Further development is needed to make the classification and tracking algorithm more robust.

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2.10. **Result #11 – Wireless Sensor Network (SP2)**

### 2.11.1. Overview and perspectives

An innovative sensing system, the wireless sensor network (WSN), which can be mounted on roadside barriers, was developed by MIZAR as part of SP2 activities. It was subsequently incorporated in the Hazard & Incident Warning (H&IW) application as a way of enhancing road safety in the case of:

- Wrong way drivers (‘ghost drivers’)
- Obstacles on the road (accidents, objects, queues of traffic)

The WSNs developed for SAFESPOT consisted of groups 3 and 10 sensing ‘nodes’, each of which contains micro-sensors (two pyro-electric and two magnetometers). The signals registered by the nodes are ‘hopped’ through the network using wireless communications. Raw data is gathered by a gateway node and sent to a roadside unit (RSU) which represents the ‘intelligence’ of the system. The H&IW application software in the roadside unit processes the data, enabling the detection of potentially dangerous conditions. In the case of an ‘event’, the RSU sends warning messages via the VANET directly to SAFESPOT-equipped vehicles and/or activates messages displayed on roadside VMS and warning lights (e.g. LEDs mounted on the nodes). As the nodes have low energy needs, they can be powered by solar panels, so that they can be used in remote rural locations without cabled connections.

![Figure 16. Sensing nodes and overall scheme of the Wireless Sensor Network system](image-url)
As a result of the research activities and pilot tests carried out in SAFESPOT, a specialised group, Consorzio SISTRA, was set up with the aim of further developing, testing and marketing commercial applications of the WSN (the group includes a research team and supplier roadside barriers). It is currently in the process of becoming a private company which plans to offer the WSN application to system integrators (including MIZAR, one of the SAFESPOT partners).

The first commercial application (Wrong Way Driver Detection) is expected to be on the market before the end of 2010. Further applications, including the detection of collisions with the barrier, traffic flow monitoring, detection of obstacles on the road (landslides or fallen rocks), traffic queues, and environmental monitoring (fog and ice) are expected to follow in 2011 and 2012 after more exhaustive testing.
2.11. Result #12 – WSN for Intelligent Transportation Systems (SP2)

2.12.1. Overview and perspectives

A WSN (Wireless Sensor Network) composed of 10 sensor nodes and a gateway node has been developed by ISMB in SP2. Each node of the network is composed of:

- a sensor board, which integrates a Pyroelectric sensor and a Magneto-resistive sensor;
- a base board, the core of the node, that contains a microcontroller, A/D converters, non-volatile memory, data-logging interfaces;
- a radio board, responsible for the interaction among the WSN nodes deployed along the roadside.

Pyroelectric and Magneto-resistive sensors which are characterized and tested indoor and outdoor, form a novel system capable of detecting speed, direction and number of vehicles. In future, detection and classification of different vehicle types could be investigated.

Figure 17. Representation of the Italian test-site and hardware details of a wireless sensor node connection

Figure 18. Italian Test-Site. The Gateway Node (GN) and Sensor Nodes SN1, SN2, SN3 are emphasized
2.12. Result #13 – CCTV camera for environmental conditions detection (fog, rain...) (SP2)

2.13.1. Overview and perspectives

Based on the French standard NF P 99-320, a sensor, developed by LCPC in SP2, is a multifunctional camera for environmental conditions detection. By means of this sensor, a given Road Side Unit can detect the following environmental events:

• Daytime fog presence
• Night-time fog presence
• Rain presence

and assign the low visibility distances in one of the four following ranges:

<table>
<thead>
<tr>
<th>Visibility range</th>
<th>Visibility distance [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>200 to 400</td>
</tr>
<tr>
<td>2</td>
<td>100 to 200</td>
</tr>
<tr>
<td>3</td>
<td>50 to 100</td>
</tr>
<tr>
<td>4</td>
<td>&lt; 50</td>
</tr>
</tbody>
</table>

This sensor aimed at feeding the SP5 applications Hazard & Incident Warning (H&IW) and Speed Alert (SpA) triggered by degraded weather conditions.

Figure 19. Results of: (a) daytime fog detection and visibility estimation (black line); (b) rain detection (green pixels)
2.13. Result #14 – Data Fusion Logic for RSU (SP2)

2.14.1. Overview and perspectives

As the name implies, data fusion is a technique for ‘merging’ data from different sources in order to produce an output which could not be obtained from a single data source. The principal aim is to improve the quality of data in terms of its reliability, accuracy, and consistency. Secondly, data fusion techniques are used to close gaps in detection, so that the potential impact of a breakdown of a single sensor can be mitigated. Thirdly, data fusion provides information which cannot be measured directly by a sensor, because the appropriate sensor or technology is not available.

The application DFL (=data fusion logic) is the software realisation of the main SAFESPOT data fusion part for the road-side unit (RSU). DFL receives UDP or SOAP messages, processes them and writes the data fusion results into the LDM database. Messages that are not trajectory related are written on the LDM without being further processed in the object refinement. DFL comprises the following components: (1) the data receiver, (2) the object matching, (3) the map matching and (4) the manoeuvre estimator.

The Data Receiver module is the ‘front end’ for the data processing. It is the standard interface responsible for acquiring data from the different data sources so that they can be made available to the data fusion process. The Object Matcher matches the moving objects captured by different kind of sensors. The aim is to identify the information originating from different sources being associated with the same moving object. The result of this process is a unique view of the moving objects in the monitored area which is stored in the LDM. The Map Matcher assigns the detected moving objects (vehicles) to an entity of the static layer of the LDM, i.e. a road element, lane are a reference track. The map matcher only deals with individual moving vehicles, not with traffic events. The Manoeuvre Estimator process estimates the path the vehicle is likely to take while passing the intersection.
Figure 20. General Concept of the RSU data fusion

The next steps will lead to an improvement of the stability and robustness of the data fusion process and to the better integration of additional fusion tasks.
2.14. Result #15 – Laserscanner system for infrastructure (SP2)

2.15.1. Overview and perspectives

IBEO has developed a Laserscanner based system for infrastructure based installation to detect, track and classify road users of any kind. It consists of one or more Laserscanners placed on an intersection roadside and a Laserscanner fusion ECU, processing and fusing the perceived data. The system architecture is depicted in Figure 21 below.

The system is able to detect and differentiate between passenger cars, trucks, motor cycle and pedestrians in the vicinity of the intersection. The average detection range for a system based on 2 Laserscanners is given in table 4 below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Detection range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger car</td>
<td>&gt;250m</td>
</tr>
<tr>
<td>Truck/ bus</td>
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<td>&gt;100m</td>
</tr>
<tr>
<td>Motor cycle</td>
<td>&gt;200m</td>
</tr>
</tbody>
</table>

The next steps will be dealing with further improvement of the algorithms in terms of robustness, downsizing of the Laserscanner itself and the reduction of production costs as well as test on alternative installation positions (e.g. on top of a traffic light pole).
2.15. Result #16 – Extended Cooperative Automatic Incident Detection - ECAID (SP2)

2.16.1. Overview and perspectives

The ECAID is a software for incident detection designed for infrastructure-side applications (Traffic Control Centres, Road Side Units), which was proved to perform well in cooperative environments.

The ECAID consists of two incident detection algorithms working in collaboration to detect sudden alterations in the traffic flow; an event is generated when there is symptomatic evidence of an abrupt traffic disruption; this enables the system to provide a warning to prevent (further) accidents.

The algorithm is fed with traffic measurements (flow, speed) coming from any type of traffic sensor, either installed on infrastructure side or deriving from the instant speed and position of probe vehicles.

The ECAID was submitted to an extensive calibration and performance assessment procedure including several scenarios produced via traffic microsimulation, where the high availability of traffic information coming from both fixed and mobile sensor networks was reproduced. The system was also validated in a real environment, with an installation on the Brescia-Padova motorway SAFESPOT test site. The results showed good performances in terms of Detection Rate (DR), False Alarm Rate (FAR) and Time To Detect (TTD), with a precision of detection improving with the availability of traffic information in terms of sensor spacing and probe vehicles penetration rate.

![Microsimulation model for performance assessment of ECAID](image)

Figure 22. Microsimulation model for performance assessment of ECAID. The algorithm was also tested in a real environment (Brescia-Padova motorway SAFESPOT test site)
2.16. Result #17 - Safety Margin Assistant – application framework and HMI (SP4)

2.17.1. Overview and perspectives

The SMA (Safety Margin Assistant) is mainly a warning system. It enhances the range of perception of the driver and detects potentially dangerous situations in advance, allowing to avoid accidents or, if this is not possible, to reduce the impact of the accident by reacting earlier than without the system. To reach this goal, the Safety Margin Assistant suggests actions to the driver resulting in safe driving conditions, regarding the dynamics of the vehicle, as well as the interaction with other vehicles in the traffic flow. By looking at the safety content provided by the Safety Margin Assistant, a classification has been adopted for the provided assistance into 3 areas, corresponding to three different stages of warning and actions to take, where the driver intervention needed to prevent the crash is increasing between them:

- **Comfort Area**: The situation should be communicated to the driver, but the driver has to react in a very comfortable way to avoid the accident;
- **Safety Area**: The situation is relevant for safety and the driver has to react in a significant timeliness to avoid the accident;
- **Critical Area**: The situation is critical for safety and the driver has to react in a very fast way and with the correct manoeuvre to avoid the accident.

In the figures below the application framework and the reference HMI for the SP4 applications are represented:

![Figure 23. Functional components of the SP4 framework](image-url)
The SAFESPOT HMI is designed as an environment where different applications present their warning messages to the user. In fact, the fundamental concept which is realised by the SAFESPOT HMI is the implementation of an open and interoperable system, capable of supporting HMI information provided by different applications. These applications can be the one developed within the SAFESPOT project or external (i.e. the CVIS ones, or other completely foreign). The same HMI, in the different implementation flavours exploited by the SAFESPOT OEMs, is able to support in a unified frame of reference, the drivers of different type of vehicles (e.g. passenger cars, trucks, motorbikes).
2.17. Result #18 - External Message Application (SP4)

2.18.1. Overview and perspectives

An important I2V application, developed by the CRF SP4 team is the External Message Application. By means of this application, a given Road Side Unit can deliver warnings or information to specific vehicles for visualization on the driver's HMI. The domain of validity for such information can be delimited spatially (by a polygonal area) and/or by a time interval. When the vehicle receives the message through the VANET, the External Message Application informs the driver by means of text messages, visual icons (pictograms) or earcons.

Figure 25. Example of usage of the External Message Application: an infrastructure application detects a ghost driver and transmits the information to the incoming vehicles

The underlying need was to support the presentation of text messages, icons and earcons in order to generate HMI presentation events independently from the occurrence of a specific SAFESPOT Use Case. In other terms, the application enables the SAFESPOT vehicle nodes to show some presentation events to the drivers. In perspective, among all of the SP4 applications, the External Message Application can be considered as the “client” enabling the implementation of a large number of I2V applications. In SAFESPOT a specific protocol was designed, implemented and tested which can be the basis for a future standardization. Its demands, in terms of computational resources at on board level are relatively moderate; consequently it can be envisaged an early deployment.
2.18. Result #19 – Road Intersection Safety (SP4)

2.19.1. Overview and perspectives

The most important V2V safety applications are the ones related to intersections, since there are, for most of the time, no other vehicle-based sensors available which are capable of supporting the driver in this situation. The Road Intersection Safety Application, developed jointly by Renault and Continental in SP4, addresses the typical dangers faced at intersections. One of the main benefits of V2V Communication is its ability to “communicate around the corner”, which is especially helpful at intersections. In order to support the driver, the road intersection applications warn him about e.g. approaching emergency vehicles, obstructed view at intersections (which is especially helpful in case of an intended left turn) or accidents at intersections.

The benefits of the cooperative approach are most visible in the case of an obstructed view. Here, normal sensors can not detect oncoming vehicles, but due to its very nature communication can bridge this gap and give information even though the drivers of the vehicles have no chance to see each other.

To give the necessary support, the vehicles transmit their position and dynamics plus some special information like the status of the indicator lights, a detected accident or an indication of being an emergency vehicle.

Figure 26. Example of Road Intersection Safety: the driver of the car gets warned about an accident even though the view is obstructed by the truck
2.19. Result #20 – Lane Change Manoeuvre (SP4)

2.20.1. Overview and perspectives

Lane Change Manoeuvre is an important V2V application developed by Piaggio and Politecnico of Milan. Nowadays, although vehicles are equipped with specific rear mirrors, occluded areas remain otherwise known as blind spots. In this situation the need arises for lane change manoeuvre support, in order to improve the information about the presence of other vehicles around the rider. This application allows the ego-vehicle to be aware of the presence of other actors next to it by transmitting their position and speed. Its aim is to avoid the lateral collision during ‘Lane Change Manoeuvre’. For instance, in the use case demonstrated during the Showcase 2010 in Amsterdam, the involved vehicles (a PTW and one passenger FIAT car) participated to a manoeuvre in which the PTW travels at a low speed on the leftmost lane and attempts a lane change trying to turn right. Meanwhile in the rightmost lane the car is approaching at higher speed. The LCM application detects the risk of collision and it warns the rider.

The results of the scenario analysis in the form of warning messages are delivered to the rider using visual messages on a LCD display and acoustic warning by the way of a Bluetooth helmet. The level of warnings depends on the distance and relative speed between the involved vehicles.

Figure 27. Representation of Lane Change Manoeuvre scenario: the Ego Vehicle is on the leftmost lane of the road while the Other Vehicle is approaching from the behind on the rightmost lane

The key aspect of the Lane Change Manoeuvre application is the possibility to inform the driver at an early stage about potential risk of a lateral collision due for instance to the presence of another vehicles in its blind spot. At the applicative level the advantages of using such a co-operative approach are very relevant. Vehicles can exchange their reciprocal position and negotiate for lane changes and share hot spot information among the cooperating vehicles.
2.20. Result #21 – Safe Overtaking (SP4)

2.21.1. Overview and perspectives

Safe Overtaking is a V2V application developed by Piaggio and Politecnico of Milan. This manoeuvre involves riders and drivers assessing the relative speeds between the ego vehicle and the one to be overtaken, evaluating the road segment characteristics that is being traversed and the presence of other vehicles either in front or at the rear, a very complex task that requires much driver decisions. The support provided by this application is related to the prevention of collision among vehicles in an overtaking situation (integration of blind spot and early notification to the preceding driver of the intention to overtake of the vehicle behind).

A PTW (EV) is running in the rightmost lane of the section road and a second PTW (OV) is in overtaking manoeuvre on the leftmost lane of the section road.

EV starts to overtake V3 in front of it. The SO SAFESPOT application detects the risk of collision and it warns the EV rider.

The results of the scenario analysis in the form of warning messages are delivered to the rider using visual messages on a LCD display and acoustic warning by the way of a Bluetooth helmet. The level of warnings depend on the distance and relative speed between the involved vehicles.

![Image of Safe Overtaking scenario]

Figure 28. Representation of Safe Overtaking scenario: the Ego Vehicle is on the rightmost lane of the road and it has in front of it a vehicle V3. Other Vehicle is overtaking EV. It is approaching from the behind on the leftmost lane

An overview of the SO application has been presented. At the applicative level the advantages of using such a co-operative approach are very relevant. Vehicles can exchange their reciprocal position and negotiate for lane changes and share hot spot information among the cooperating vehicles. The continuous sharing of information amongst all actors within a transportation system is the major contribution from co-operative vehicles to safety and to vehicle traffic. Data collected by full SAFESPOT vehicles could be sent to traffic control centres where it will be fused and processed. This can then be broadcasted by various means to other SAFESPOT actors or other vehicles.

As a result an improvement of the situation awareness of all the drivers involved over extended areas can be obtained.
2.21. Result #22 - Head On Collision Warning (SP4)

2.22.1. Overview and perspectives

An important V2V application, developed by the CRF SP4 team is the Head On Collision Warning. In this application the situations of head to head collisions are prevented by means of the cooperative approach. For instance, in the use case demonstrated during the Showcase 2010 in Amsterdam, the three involved vehicles (two heavy trucks and one passenger car) participated to a manoeuvre in which the first truck travels at a low speed on the right lane and the car attempts a lane change manoeuvre, with the intention of overtaking the truck. In the meanwhile the second heavy truck, approaching from the opposite direction, is facing a situation with a risk of a head to head collision. The cooperative approach is used to prevent the potential dangerous situation, by means of a suitable warning advice. Whenever the driver of the car decelerates and retract from the overtaking, the warnings disappear from the vehicle display. The level of warning will also depend on the distance and relative speed between the involved vehicles.

![Figure 29. Representation of one sample scenario for the Head On Collision Warning: the truck travels at a low speed on the right lane and the car attempts a lane change manoeuvre](image)

The key aspect of the Head On Collision Warning application is the possibility to inform the driver at an early stage about potential risk of a head to head collision due for instance to the reduced speed of the preceding vehicles or, in case of two ways roads, due to overtaking manoeuvres that the vehicles in the opposite traffic direction have started. The cooperative vehicles communicates, directly to the other vehicles their position and dynamics in order to evaluate the risk of a head to head collision.
2.22. **Result #23 - Rear End Collision Warning (SP4)**

2.23.1. **Overview and perspectives**

An important V2V application, developed by the CRF SP4 team is the Rear End Collision Warning. In this application the situations of head to tail collisions are prevented by means of the cooperative approach. For instance, in the use case demonstrated during the ITS 2009 World Congress in Stockholm, the two involved vehicles (one motorbike and one passenger car) participated to a manoeuvre in which the first vehicle – the passenger car - travels at a low speed on the lane and the motorbike approaches from behind at a higher speed. The cooperative approach is used to prevent the potential dangerous situation, by means of a suitable warning advice. Whenever the risk of a rear end collision decreases (for instance in case the motorbike decelerates), the warnings disappear from the vehicle display. The level of warning will also depend on the distance and relative speed between the involved vehicles.

![Figure 30. Representation of one sample scenario for the Rear End Collision Warning: the passenger car travels at a low speed on the lane and the motorbike approaches from behind at a higher speed](image)

The key aspect of the Rear End Collision Warning application is the possibility to inform the driver at an early stage about potential risk of a head to tail collision due for instance to the reduced speed of the preceding vehicles. The cooperative vehicles communicates, directly to the other vehicles their position and dynamics in order to evaluate the risk of a head to tail collision.
2.23. Result #24 – Speed Limitation and Safety Distance (SP4)

2.24.1. Overview and perspectives

An important V2V and I2V application, developed by the MMSE SP4 team is the Speed Limitation and Safety Distance. The SLSD application has the purpose to detect if there are vehicles ahead in the same lane, or if they are on a different lane and their trajectory intersects the current trajectory of the vehicle. In this case the application estimates the risk of collision between the vehicles. In case of a dangerous situation the driver of the vehicle is warned to keep the safety distance. If on the test site there is a Road Side Unit sending the dynamic change of speed on some road elements, the vehicle receives this information. Then, the Speed Limitation and Safety Distance application evaluates if the vehicle is moving with a speed which is lower than the limit value, and in case it warns the driver to keep the right speed. The Speed Limitation and Safety Distance Application informs the driver by means of visual icons (pictograms).

![Figure 31. Example of usage of the Speed Limitation and Safety Distance Application: vehicle n°1 detect the distance from front vehicle and visualize the pictogram in the display](image)

In SAFESPOT a specific protocol was designed, implemented and tested which can be the basis for a future standardization. Its demands, in terms of computational resources at on board level are relatively moderate; consequently it can be envisaged an early deployment.
2.24.   Result #25 – Frontal Collision Warning (SP4)

2.25.1. Overview and perspectives

Frontal Collision Warning is a V2V and I2V application developed by Volvo. This application warns the driver about potential collision with vehicles in front. The application benefits significantly from the cooperative approach and increase the safety margin for the driver in critical driving situations. For instance, a use case that demonstrates the benefit of the cooperative approach for the Frontal Collision Warning application was demonstrated during the ITS 2009 World Congress in Stockholm and during the Showcase 2010 in Amsterdam. In this use case, two trucks are approaching a stopped car, where the presence of the stopped car is obstructed for the truck behind. The cooperative approach is used to prevent the potential dangerous situation, by means of a suitable warning advice. The level of warning depends on the distance and relative speed between the involved vehicles. Whenever the risk of a frontal collision decreases, the warnings disappear from the vehicle display.

![Representation of one sample scenario for the Frontal Collision Warning](image)

Figure 32. Representation of one sample scenario for the Frontal Collision Warning: two trucks travel in the direction of a stopped car, where the presence of the stopped car is obstructed to the truck behind

The Frontal Collision Warning application is based on cooperative information that can come either from V2V or from I2V. The Frontal Collision Warning application can based on the cooperative information inform the driver at an early stage about a potential risk of collision in front, and thereby increase the safety margin for the driver.
2.25. Result #26 – Road Condition Status – Slippery Road (SP4)

2.26.1. Overview and perspectives

Road Condition Status – Slippery Road is a V2V and I2V application developed by Volvo. This application informs the driver about slippery road ahead. The application benefits from the cooperative approach where sensor information can be shared in order to make traffic safer. For instance, in the two use case demonstrated during the ITS 2009 World Congress in Stockholm, two trucks are approaching a slippery area. The first truck can sense the slippery area and can send the sensor information using V2V or V2I so that the truck behind can be informed about the slippery area ahead and can adapt the speed to a safe speed before entering the slippery area. The data source was either sent directly V2V or via a road side unit (V2I) to demonstrate possible data sources for this cooperative application. The cooperative approach is to share sensor information in order to make traffic safer, by means of warning advices.

![Diagram of two trucks approaching a slippery area](image)

Figure 33. Representation of two sample scenarios for Road Condition Status-Slippery Road: two trucks travel in the direction of a slippery area with and without infrastructure support

The application Road Condition Status –Slippery Road is based on cooperative information that can come either from V2V or from I2V. This application can based on the cooperative information inform the driver at an early stage about a slippery road ahead, so that the driver can adapt the speed in safe manner.
2.26. Result #27 - Curve Warning (SP4)

2.27.1. Overview and perspectives
An important I2V application, developed by the CRF SP4 team is the Curve Warning. In this application information is gathered and delivered with a sufficient anticipation to the driver about the proper trajectory to keep in this specific black spot, including information about the road curvature and the adequate speed. Conditions that may dynamically change the speed and the trajectory to keep in the curve (road works, static obstacles) are also tackled.

The entire Curve Warning application consists into two separate phases: a preliminary learning phase where the primary actor is the Road Side Unit located close to the curve and a driving support phase where the principal role is carried out by the vehicle. During the learning activity the infrastructure acquires data from the beaconing messages of several probe vehicles driving through the curve. When it has collected enough information, the Road Side Unit elaborates a set of proper trajectories for travelling the curve.

In the driving support phase a host vehicle, approaching the curve, receives a suggested trajectory from the infrastructure. In this way the vehicle is able to analyze the scenario, comparing its behavior with the recommended trajectory, sent by the RSU, and to detect possible critical situations for the driver.

![Diagram](image)

**Figure 34. Representation of one sample scenario for the Curve Warning: Host vehicle (1) transmits to a RSU (3) its speed and other vehicle dynamics information. In a second time a vehicle approaching to the rural black spot (2) receives the recommended trajectory, adapting its speed and lateral position**

Concerning the Curve Warning, it should be evidenced as example that by means of broadcasting of information from the host-vehicle, also a vehicle approaching a sharp curve without any digital maps or other navigation systems installed on-board, can travel inside the curve safely (with the suggestion of reference trajectory to keep). On the other hand, if the vehicle is already equipped with digital maps, the information of how other vehicle behold in the same situations can help to reduce the number of false and missing alarms.
2.27. \textbf{Result #28 – Vulnerable Road User Detection and Accident Avoidance (SP4)}

\textbf{2.28.1. Overview and perspectives}

Vulnerable Road User Detection and Accident Avoidance is a V2V application developed by Volvo. This application warns the driver about potential collision with vulnerable road users (e.g. pedestrians) in front. The application benefits from the cooperative approach where sensor information can be shared in order to make traffic safer. For instance, in the use case demonstrated during the ITS 2009 World Congress in Stockholm, two trucks are approaching a pedestrian that is crossing the road. When the first truck slows down for the pedestrian in the right lane, the approaching truck starts overtaking in the left lane. The first truck is obstructing the view of the pedestrian for the overtaking truck. The first truck is equipped with an IBEO laser scanner that can detect pedestrians, and the presence of the pedestrian is communicated using V2V to the overtaking truck. The cooperative approach is to share sensor information in order to make traffic safer, by means of warning advices.

![Figure 35. Representation of one sample scenario for the Vulnerable Road User Detection and Accident Avoidance: a vehicle is overtaking a truck that has stopped to let a pedestrian pass the road](image)

The Vulnerable Road User Detection and Accident Avoidance are cooperative applications which inform the driver at an early stage about a potential risk of collision with vulnerable road users (e.g. pedestrians) ahead. The cooperative vehicles communicates its sensor information to the other vehicles when there is a risk for collision with vulnerable road users, and the cooperative information can be used to warn the driver at an early stage about the potential collision with vulnerable road users ahead.
2.28. Result #29 - Speed Alert - Critical speed warning - legal (SP5)

2.29.1. Overview and perspectives

The Speed Alert – Critical Speed Warning - legal is based on communication between the RSU and the surrounding vehicles; two subcases can be distinguished: normal transmission of legal speed limit and warning associated and dynamic modification of the legal speed limit.

Normal transmission of legal speed limit and warning associated: This is the normal behaviour of the application which monitors vehicles in the surrounding and sends the legal speed limit to each vehicle, according with their position. Moreover, the application also warns vehicles when their speed is higher than the legal limit.

Dynamic modification of the legal speed limit: In this scenario, the legal speed limit is set up dynamically according to various events: weather events, pollution events. Moreover we offer to the road operator the possibility to set up directly the legal speed limit. For instance, close to a school, when children enter or leave, the speed could be set at 30km/h. Vehicles are then warned accordingly with the dynamic legal speed limit.
2.29. Result #30 - Speed Alert - Critical speed warning - dynamic (SP5)

2.30.1. Overview and perspectives

The Speed Alert – Critical Speed Warning - dynamic is based on communication between the RSU and a vehicle; with a deep knowledge of the road geometry and the weather condition, the RSU is able to define a speed profile to cross a road difficulty safely. The RSU warns the vehicle in case of over speeding with a road sign describing the difficulty (a left turn, for instance) and a message asking the driver to decelerate.

Figure 38. Component diagram of the Speed Alert - Critical speed warning – dynamic
2.30. Result #31 - Hazard and Incident Warning – Obstacle on the road (SP5)

2.31.1. Overview and perspectives

The Hazard & Incident Warning - obstacle is based on communication between the RSU and the surrounding vehicles; two subcases can be distinguished: roadwork as an obstacle and vehicle as an obstacle.

Roadwork as obstacle: When the obstacle results from the roadwork, position and lane occupation of the roadwork are sent to the RSU from the motorway control center. This data is then inserted into the LDM and the application sends different type of message toward approaching vehicles:

First, a repetitive broadcast message is sent to dispatch the information to all the vehicles entering the area covered by the radio range of the RSU.

On the other hand, the RSU application continuously monitors the approaching SAFESPOT-ready vehicles; from the vehicle position and speed received via the beaconing messages sent by the OBU, it computes for each vehicle the time to collision with the obstacle. According to that time, each vehicle receives either a “Safety Warning Message” (remaining time between 10 and 2 seconds) or a “Critical Safety Message” (remaining time lower than 2 seconds).

Vehicle as obstacle: In this scenario, when a SAFESPOT-ready vehicle stops on the road, it automatically sends its position and problem identification to the RSU; then, the vehicle position is inserted into the LDM as an obstacle, and the same scenario as in the previous subcase is started in order to alert the approaching vehicles.

Figure 39. Hazard & incident warning application - West Test Site Implementation
2.31. Result #32 Hazard and Incident Warning – Wrong Way Driving (SP5)

2.32.1. Overview and perspectives

An innovative application, the Hazard and Incident Warning – Wrong Way Driving, was developed by MIZAR as part of SP5 activities. It is based on an innovative Wireless Sensor Network which constitutes its road side detection subsystem.

The objective of the system is to detect a vehicle travelling in the wrong direction and to generate warning messages for approaching vehicles risked a collision. The warnings are delivered both via roadside devices (e.g. VMS) and are also sent by the roadside unit (RSU) to the HMI of the SAFESPOT vehicles through the I2V communications channels of the VANET.

The roadside sensing technology adopted was the Wireless Sensor Network (WSN) developed in SP2.

Figure 40. Overall scheme of the Hazard & Incident Warning - Wrong Way Driving application
2.32. Result #33 – Intelligent Cooperative Intersection Safety - IRIS (SP5)

2.33.1. Overview and perspectives

Application IRIS aims to protect the road-users from safety critical situations in the vicinity of urban intersections by providing recommendations and warnings in time. Typical critical situations addressed by IRIS are red light violations, left and right turns with intersecting traffic.

The IRIS System is not a stand-alone application at the urban intersection. The success of the application depends on the one hand on an advanced sensing and data fusion system and on the other hand on a fully developed HMI in the vehicle as well as an alert system at the infrastructure side.

The basis of the whole system is the sensing systems which deliver their output to the data fusion unit. The data fusion also receives input from the probe vehicles via the Vehicle Ad hoc Network (VANET) as well as input from the applications. The fused data is fed into the Local Dynamic Map (LDM). The LDM is a real-time or near real-time geometric representation of relevant infrastructure and non-infrastructure features and objects in the vicinity of the RSU. Therefore, the IRIS Application works in close cooperation with the RSU data fusion DFL and the LDM. Based on the processed data the IRIS application assesses the evolving situation and decides whether there is the need to warn the driver or not by the use of the VANET.

The next steps will be the enhancement of the interaction of IRIS with the DFL and the message component. Furthermore, the integration of camera based information at the urban intersection is a major task. It will certainly take a while until this kind of application will become reality, because of the high quality requirement on safety systems.
2.33. Result #34 - Road Departure Prevention (SP5)

2.34.1. Overview and perspectives

Based on infrastructure to vehicle communication, the Road Departure Prevention application (RDEP) aims to reduce the number of occurrences that a vehicle departs from the road. The application monitors the dynamic behavior of vehicle passing through black-spots, such as deviation for roadwork or dangerous curve, and when a risky situation is foreseen, a warning message is sent to the driver.

The RDEP application consists of two phases. In the first phase, the application obtains the values of the dynamic parameters of probe vehicles driving through the coverage area and then processes the information to set the safety and critical limitations for those parameters. The output of this learning phase is stored into the Safe Drive Map (SDM) database.

In the second phase, the application monitors in real-time the black-spot area. The information coming from the vehicle’s beacon in real-time is used to predict a near future trajectory and the result is compared with the information previously saved in the SDM. When the vehicle’s behavior is found risky, the application warns the driver about the possible dangerous situation.

Figure 42. Road Departure Prevention main scenarios: deviation for roadwork on the left and dangerous curve on the right

The Road Departure Prevention application was tested in a simulation environment and in two different test sites. Deviation for Road Work and Dangerous curve were the two scenarios used to test the application. Warning messages were accurately produced by the application and sent to the driver. The tests showed that the SDM concept was useful and optimal for the RDEP application. However, calibrating the near future trajectory prediction module was difficult and time consuming.
2.34. Result #35 - Safety Margin for Assistance and Emergency Vehicles - (SP5)

2.35.1. Overview and perspectives

The Safety Margin Assistance Safety Margin for Assistance and Emergency Vehicles application covers two different scopes. One is to provide priority for emergency vehicle crossing an intersection and the other one is for helping assistance vehicle (for road stakeholder) to inform road users of an event they will face on the road.

The perspective of these two applications is depending for what has been done on SAFESPOT on the reliability of the SAFESPOT platform. The concept developed could be reused on any environments but currently, only the SAFESPOT environment is supported and works.

![Figure 43. SMAEV – 01, as implemented on a mobile Road Side Unit (left), and SMAEV – 02 (right) layouts](image)
2.35. Result #36 – Vehicle client application for IRIS (SP4)

2.36.1. Overview and perspectives

Having received a message from a RSU, the vehicle system checks the relevance with the data of the ego-vehicle from its own LDM. If necessary, the system brings a warning signal to the driver. If the message is dedicated to “this” vehicle, the HMI warning is activated immediately without relevance check. The application HMI of Continental’s SAFESPOT system consists of visible and audible signals. In the future, also haptic signalling is considerable.

Figure 44. Pedestrian on right side

Figure 45. Remaining Green Time
2.36. Result #37 – SAFESPOT deployment programme

2.37.1. Overview and perspectives

The SAFESPOT deployment programme describes deployment challenges, recommendations and different scenarios for the deployment of cooperative safety systems in the context of cooperative systems in general. It is based on the many issues that have been researched during the course of the SAFESPOT. It focuses on:

- the organisational architecture and, in particular, the analysis of roles and responsibilities;
- risks and legal analysis;
- impacts and cost-benefit assessment;
- business models and market assessment.

![Figure 46. Scope of the SAFESPOT Deployment programme](image)

The scope of the deployment programme starts in the year 2010, with cooperative warning systems that extend the horizon of the driver to minutes before the potential crash.

Where the scope of the SAFESPOT project is limited to:

- Cooperative systems (factory-fit and nomadic);
- Safety functionality;
- Warning systems;
- Short range communication based on IEEE 802.11p.

The SAFESPOT deployment programme describes a transition path towards cooperative safety systems. The scope of that transition path contains:

- Cooperative and standalone systems (factory-fit and nomadic);
- Safety, comfort, navigation, infotainment and traffic management functionality;
- Warning systems and active systems (e.g. adaptive cruise control and emergency breaking);
- Short range communication (based on IEEE 802.11p) and long range communication (based on cellular network, e.g. GPRS).
2.37. Result #38 – SAFESPOT Certification Reference Framework

2.38.1. Overview and perspectives

The purpose of Certification Reference Framework is to provide indications for the technical subprojects of SAFESPOT and in general, to all actors involved in the building of cooperative systems, on how to interpret and use the SAFESPOT Global System Reference Architecture to build their own architectures. It presents the main features of the Reference Architecture, covering the following topics:

- Discussion of the role of the Reference Architecture in SAFESPOT;
- Description of the architecture-building process adopted;
- Recommendations for the cooperative systems developers and users on how to define:
  - the User Needs and System Requirements
  - the Functional Architecture and Data Flows
  - the Physical Architecture
  - the Communications Architecture
- Indications for the future maintenance of the Reference Architecture.

One of the principal objectives of the adopted methodology on the Certification Reference Framework is to ensure that all of the component parts of the system are interoperable. It also plays an important role in guaranteeing that the final systems meet the requirements of its users.
2.38. Result #39 – SAFESPOT Contribution to the European Harmonised Cooperative Architecture

2.39.1. Overview and perspectives
The SAFESPOT User Needs and Functions represent an exploitable and direct extension of those in the current version of the European ITS Framework Architecture.

Relationship with EITSFA

![Diagram of the relationship between SAFESPOT and EITSFA](image)

**Figure 48. Contributions of SAFESPOT and relationships with the European ITS Framework Architecture**

The adopted system requirements consist of a statement in natural language of what services or functions the system is expected to provide and the constraints under which it must operate.

A set of high level requirements has been compiled within SAFESPOT for aspects of relevance for the system as a whole including: modularity, interoperability, security, performance, communications and safety systems. The technical subprojects were provided with guidelines for compiling their own system requirements. These must state what each component or element of the system is required to do in order to satisfy the high level requirements and the User Needs or Use Cases.

System requirements fall into one of three categories:

- **Functional** (what the system need to be able to do)
- **Non functional** (system performance or quality requirements)
- **Context** (e.g. a system constraint).
2.39. Result #40 - SAFESPOT Conformance Test System (SP7)

2.40.1. Overview and perspectives

Testing has been and currently is one of the key parts in the way to put and achieve a success and excellent equipments. Different types of testing could be used to check several requirements implemented in any equipment, but nowadays the crucial aspect to achieve is the complete interoperability between equipments. The first step to get this interoperability is to check that the equipment is compliant with the technical specification.

This process is complex and tedious. The use of automated test tools is an interesting solution to accelerate the test process. It improves efficiency, quality and reliability, since manual test operator intervention can always be considered as a source of uncertainty. Also the use of standardized methods like TTCN-3 test specification language improves cost efficiency and save time.

SAFESPOT Conformance Test System has been developed in the context of SAFESPOT project based on a set of test specification, which were also specified in SAFESPOT, and using TTCN-3 languages. This test tool is focused on checking how a equipment is compliant with its technical specification; concretely the test tool mainly checks the beaconing functionality described in SP3. One example of the functionality checked is the message format and adaptation of message content due to changes in either the position or the speed.

![SAFESPOT Conformance Test System](image)

**Figure 49. SAFESPOT Conformance Test System**

As it was mentioned, the SAFESPOT Conformance Test System is based on a TTCN-3 Test Architecture. The test system developed here is structured into three layers: the Test Operator, the Test Handler and the Test System Management. The Test Operator is in charge of selecting and configuring the test cases to be executed; the Test Handler allows selecting the tests to be executed and inserting test parameters. Finally, the Test System Management is considered the heart of the test system executing the test cases, generating logs, exchanging data with the Equipment Under Test, etc.
2.40. Result #41 – SAFESPOT Organisational Architecture (SP6)

2.41.1. Overview and perspectives

This work investigates and attempts to envisage the organisational structure that will characterize future cooperative systems and SAFESPOT in particular. Due to the complex nature of such systems, all the functionalities, responsibilities and relationships need to be well defined and outlined, as a prerequisite for a risk-safe involvement of stakeholders.

In order to carry out the analysis, an existing methodology (Italian ITS reference architecture ARTIST) was adapted to the description of V2V and V2I cooperative systems. The approach suggested by the ARTIST methodology is based on the concept of role. Roles can be seen as elementary organisational units, i.e. groups of homogeneous functionalities, assumed by specific organisations or stakeholders in each different implementation case.

A set of thirteen roles needed for the generic cooperative system implementation was formalized. These roles were profiled in terms of motivations, commercial, institutional and legal responsibilities, and related activities. Furthermore, a net of relations (needed agreements and business arrangements) between the SAFESPOT stakeholders was detected and described.

The Organisational Architecture diagrams show the exchanges and relations between the various roles involved. Five different groups of interrelationships between the parties were created in order to distinguish the different levels. The diagrams were used to depict the organisational structure of different layers of the SAFESPOT system (operational, implementation, global) and of cooperative systems in general.

The methodology for organisational analysis and representation was also applied to study the different hypotheses of Business Models and Deployment Scenarios, and some "almost real" cases represented by the project test sites.
Figure 50. Organisational Architecture diagram for a generic cooperative system
3. Industrial Perspectives

3.1. Integration into Infrastructure

In this section, some considerations regarding the industrial perspectives related to the integration into the infrastructure of the cooperative systems are presented.

3.1.1. The Urban Area

In urban environment there is a very dense and complex road network, with many intersections managed by traffic light controllers. Also, different types of users like pedestrians or bicycles are characteristic for the urban area. Because of the often very high traffic loads in these areas, the traffic flow is prone and sensitive to any kind of disturbance like slow moving trucks loading and unloading. In intersection, irregularity influences the flow of traffic in a wide area of the network and increases the risk of accidents. It has been highlighted, that around 45% of urban accidents occur in intersection. In this context, the intersections are considered as the main “black spots” for urban area.

This is not very surprising. The vehicle driver approaching an intersection is loaded with different problems and decisions. The driver has different opportunities for the intended driving direction: crossing the intersection, turning left, turning right or u-turning. The driver has to keep an eye on several points to avoid any misjudgement even if everybody is obeying the traffic rules, and must pay attention to pedestrians, cyclist and other potential vehicles crossing his way.

![Figure 51. Integration into infrastructure: the Urban Area](image-url)
architecture is under development to combine the already existing sensor systems and traffic light controllers at the intersection.

Based on this input the application calculates the exact trajectories of each road user and a prediction considering further information will be done. Using these trajectories critical situations are going to be identified and the alert systems being actuated.

3.1.2. The Rural Area

The rural and secondary network is a huge network, with respect to other network. Moreover, the secondary and rural roads cover mountains, forests and low density of population areas. These areas limit the range of many sensors as GPS and communications, and deployment of these sensors or communication point could be too expensive in comparison with the potential gain in terms of hazard prevention.

Also, in some countries, secondary and rural roads belong to local authorities and the management of these roads is often not centralized. This means that, between two departments, the level of road services may vary significantly. The problem is especially critical. Indeed, while on a highway the road manager is the same on a long distance - so there is no inter-operability problem - on a secondary an rural roads, there’s often a change of road manager, that is on a normal driving situation the driver can cover, in a short period, several road segments belonging to different local authorities.

Another specificity of the secondary and rural roads is the low availability of energy points. Some architecture components need energy to handle communication and some part of data computing. Solutions, as solar battery or energetic independent sensors, shall be envisaged, but may set limits to the functionality of components.

Given the specificity described previously, both energetic access and communication coverage define the need for different architectures:

- The first kind of area is a normal area with access to energy. In these areas the system architecture does not differ from the one previously outlined, and most of the applications shall be supported.

- The second kind of area are areas which does not allow easy provision of energy and (or) communication means. In fact, on secondary and rural roads, this kind of area can be mountains or large forest. Bringing energy, as well as communication with a centre, would be very expensive and global communication functions shall not be supported. As these areas can also have black spot, it shall support some basic SAFESPOT functionality. So, a specific solution with a minimum data transfer, very short range communication not in IEEE 802.11p, and auto-power supply is investigated.

3.1.2. The Motorway Area

On motorways, the concept of static “black spot” is not as relevant as for the other part of the network. The majority of lethal accidents in Europe still occur on straight roads. But we must consider that some part of the network, like the bridges or the tunnels, represent critical areas. In these “black spots”, managing an accident is
difficult and often no alternate road is available. This lead to non acceptable traffic jams in case of accident. So, in motorways, the SAFESPOT applications must deal with two main types of situation:

- Static "black spots" where particular road configurations – tunnel, bridge, heavy traffic section, complex exchange – lead to a certain accident probability and a particular need of supervision from the road operator;

- The rest of the road network composed of long straight lines and smooth curves where accident causes are mostly independent of the infrastructure.

For economic reason, those two types of situation are not treated in the same way by the highway operator.

When a static black spot is clearly identified, additional equipment is installed to improve the road safety. Typically, the car density can be monitored with regularly spaced magnetic loop and/or camera installed to provide detailed information to the system. Variable message signs are deployed to allow displaying variable speed limits and other dynamic information.

These pieces of equipment are costly to install since cables have to be buried under the carriageway, connected to road side cabinet, and powered - which means connection to the electrical network. These works generally require traffic interruption, or at least limitation, and therefore have to be performed at night. Such a density of equipment couldn't be envisaged along the entire length of the motorways.

A second level of equipment is then proposed for the straight parts of the motorways that are not identified as static “black spots”. In these sections, regularly spaced communication devices will be deployed, without providing a full coverage on the section. Also, no additional sensors are deployed. In these section, the applications will mainly be based on the information provided by equipped vehicle, and will use vehicles to broadcast information on non covered areas.

![Figure 52. Integration into infrastructure: the Motorway Area](image)
3.2. Integration into Vehicles

The SAFESPOT system deployment into vehicles as Original Equipment deals with the complex matter of optimal integration into the E/E architectures and their components (ECUs).

Each OEM have their proprietary E/E solutions normally designed with their tier 1 suppliers capable to fit the specific brand requirements both in term of functionalities, distinctive aspects and target cost.

We can imagine that the SAFESPOT paradigms implementation may be presented to the driver (in particular for the HMI) in a different way; this will depend on the car segment and type, as well as the different vehicles manufacturers and automotive suppliers, as we can see for example in the actual instrument clusters.

Nevertheless, as happened in the actual vehicle systems, the probable trend will be to share as much as possible the technical solution also among different suppliers; typically all the contents that are not visible and do not contribute to the differentiation of the functionality should be the same.

That’s what today refers for instance to the CAN bus or AUTOSAR solutions.

This deals with the adoption of common standards thus allowing the possibility to reach large volumes.

The main in vehicle components developed and successfully experimented in the SAFESPOT project can be resumed in:

- Wireless Communication (IEEE 802.11p) and Router
- Positioning
- LDM (Local Dynamic Map)
- Data Fusion Platform
- Applications
- Vehicle Gateway
- ADAS devices (Laser Scanner, Camera…etc)
- Intern Communication Modules
- HMI
- SAFESPOT SYSTEM MONITOR (ESPOSYTOR)

HMI issues was more addressed in other projects (i.e. AIDE, PREVENT…); they are not in the main activities of SAFESPOT, nevertheless HMI is a fundamental component to be considered in the overall architecture perspectives.

The SAFESPOT System Monitor ESPOSYTOR plays an important role inside the project. The ESPOSYTOR paradigm in the real deployment of the system can be assimilated as a monitoring and testing tool for developers.

Each one of the above functional components should find the appropriate physical allocation into existing or new ECUs, depending on the proprietary vehicle architecture. As we can see as example in the actual vehicle E/E architectures the CAN bus communication become a standard “the facto”, but each car manufacturer has developed his own internal solution for the uppers layers (i.e. Message Map, Inter Nodes application protocols, Network Management…etc).
Integrated vs. distributed allocation should be also a matter of the specific design solution: more components may be aggregated in a single ECU or a dedicated processor depending on cost and performance aspects.

Relevant European OEMs and Suppliers belong to the SAFESPOT consortium, such as: CRF, DAIMLER, RENAULT, VOLVO, PIAGGIO, BOSCH, Continental Automotive, Magneti Marelli. The solutions and market approaches described in the following sections have been largely discussed and agreed among all of them. Furthermore the European Council for automotive R&D (EUCAR) established specific Integrated Safety Program Board meetings, where the SAFESPOT deployment variants have been discussed and obtained an even larger consensus and agreement. In a very short summary, the vehicle architectures may be different, but it is always possible to imagine the following 3 different industrial and consequently market approaches, belonging to the roadmaps of the European OEMs and Suppliers (all the ones supporting the C2C-CC).

### 3.2.1. Stand Alone SAFESPOT plug-in

![Figure 53. Representation of the Stand Alone SAFESPOT plug-in concept](image)

This first solution considers the SAFESPOT system as a complete add on components set including also his own HMI.

The connection to the in-vehicle data is desirable but not mandatory.

In such a case the safety applications will be limited to that ones not requiring punctual internal vehicle status and information.

Functions based on road condition monitoring or using vehicle sensors in this case are excluded. The speed is limited in accuracy and there is not information on the yaw rate. All these factors are limiting the number of functionalities.
Nevertheless this should be probably the ideal architecture for retrofit solution for old and already in circulation vehicles.

Applications suitable for this configuration are the ones based mostly on information services and general traffic warnings (for instance speed limitation advice in proximity of the RSU, warning for the presence of dangerous bend, advices for road works, etc.).

### 3.2.2. Partial in vehicle integration

![Figure 54. Representation of the Partial in vehicle integration concept](image)

This is the case in which some part of the SAFESPOT components is deployed in the existing in-vehicle series components. As an example the HMI may take place in the Instrument Cluster or in the embedded Navigation System.

The synergy with existing in-vehicles core components deals with cost optimization as well as a better distribution of the functionalities inside the E/E vehicle architecture.

Several Cars E/E systems are offering today the possibility to be connected with external devices (Cell Phones, Portable Navigators, PDA...). For instance in the FIAT Group vehicles this is done using Bluetooth connection to the in Car Blue&Me device.

Such a type of connectivity should be useful in the future to extend the possibility of connection to external sub-systems like SAFESPOT, implementing what in the actual demonstrators has been done with the Vehicle Gateway device.

Applications suitable for the partial in-vehicle integration are all the ones developed and demonstrated in the SAFESPOT project. Here the constraining factor depends on external factors: since these application will most probably run on external devices (Cell Phones, Portable Navigators, PDA...), then the number and the actual
set of these applications will depend on the characteristics of these devices and on the marketing strategies of selling these external products. Of course, in this case, the role of the SAFESPOT certification bodies will be of paramount relevance (see deliverable D7.4.3 – “SAFESPOT Certification Reference Framework” for a further deepening of this aspect).

3.2.3. Fully Integrated System

In this case all SAFESPOT components have their own defined and designed place inside the E/E architecture. This means both the integration into series components as well as in dedicated electronics but specifically designed for the vehicle system.

This is the optimal solution: the OEM optimized design deals with a possibility to reach greater performance respect the two previous solutions. Reliability of the system and ergonomic aspects will gain the advantage of a tailored specific solution for each vehicle.

Applications suitable for this configuration are the ones developed and demonstrated in the SAFESPOT project. In this case no constraints exist, at least in principle, to the number and type of applications supported by this type of platform. Also the issues of certifications are automatically solved, since the applications will be provided directly by the OEM which is producing the equipped vehicle.

3.2.4. Components allocation

In the SAFESPOT project the above mentioned main components have been distributed in several PCs. It was not in the aims of the project to reach optimization of the performances, nevertheless the achieved testing results should provide important indications to be taken into account for the future industrial deployment.

In the following some example of the topics to be solved for optimal components allocation is described.

Let’s start with the example of the LDM.
This is a key component of the SAFESPOT system in which the performances in the time domain are crucial. Access query time in both read and write modes should be assured in the respect of the Safety Margin constraints assuring the correct behaviour also in critical condition, when for instance an overhead of accesses are due to an high numbers of actors (vehicles and RSU) acting in a crowded scenario.

LDM is a component that can gain the benefit of an optimal embedded design with a dedicated and optimized engine. A tailored Co-processor integrated in a controller IC is one of the possible solution. This deals of course with the matter of production volumes and the necessity, if possible, to extend as much as possible the standardization of the solutions.

Another crucial aspect is the communication (VANET).

The IEEE 802.11p device is expected to gain pretty soon the benefit of large volume scale; nevertheless the associated Router functionality has to assure, for the same motivation mentioned for the LDM, a compliant behaviour in the time domain. Thus, it is probable that Routing features should be implemented and adequately optimized in an embedded dedicated engine. For the same reasons the possibility to reach a common standard also in the upper layers of the communication channel may allow great potential for increasing volumes and reduce the overall cost of the associated devices. Here the common component to use will be most probably a dedicated “low cost” 802.11.p modem. The current very large penetration of low cost WI-FI components (802.11.x) makes this hypothesis as the most promising and largely probable.

HMI is not in the core activities of SAFESPOT project, but the related components are an important part of the system that needs to be managed in a proper manner. A Safety system should be supported by an adequate HMI capable to deliver the right information at the right time, in appropriate way (visual, acoustic, haptic,...) depending on the level of importance and the driving context. Ideally HMI should find place inside the vehicle basic information systems (i.e. Instrument Cluster), but can be improved using more enhanced interfaces.

TFT re-configurable screen, Infotainment and Navigation systems, or HUDs can provide nice way to deploy the information to the driver. Nevertheless, low cost / low segment vehicles should be equipped in a minimal way, capable in any case to delivery the SMA (Safety Margin Assistant) information in an essential manner. Here the common component to use will be the one already adopted (with minor adaptations) by the vehicle Instrument Cluster.

Applications deployment is more a matter of computation and memory availability. It is expected that in the future year this will not represent the main problem. SAFESPOT Application probably will find the proper collocation inside the evolution of the infotainment system. In this case, for all of the SAFESPOT applications, there will be no need to identify a specific common component sustaining these applications. As already demonstrated with the AUTOSAR approach, the distribution of applicative software into the existing hardware nodes of the modern E/E vehicle architectures is not an issue. The SAFESPOT applications will run most probably on the HW platforms already present in the vehicles. This could be the Instrument Cluster processing unit, for instance, or on whatever other architecture node having the sufficient computational power available to sustain the SAFESPOT applications.
Vehicle Gateway is one of the components that are more dependent from the specific and proprietary E/E architecture. Nevertheless we can assume that, the most important vehicle-related parameters for SAFESPOT, i.e. speed, light and brake status…., should be standardized in such a way. We can see as an example what happened for instance in the OBD Scan Tool in U.S. So, allowing these parameters to be exported in a common way to the SAFESPOT systems.

As previously mentioned, Several Cars E/E systems are offering today the possibility to be connected wirelessly with external devices; this feature should be another possibility to deploy the in vehicle parameters to the SF systems.
4. Technological Roadmap (*)

4.1. EUROPEAN status for C2X

On August 5\textsuperscript{th} 2008 the EU commission decided on the harmonised use of radio spectrum in the 5875 - 5905 MHz frequency band for safety-related applications of Intelligent Transport Systems (ITS) by allocating that frequency band.

EU member countries are requested to put this frequency range into their national frequency allocation plan, to enable such “Car to Car and to Infrastructure” systems.

The EU and major member countries fund projects to investigate and develop such C2X systems (based on IEEE 802.11p) in the 5.9 GHz band for mass use beyond 2013.

Running and future activities in the C2X domain will be sustained by the European FOTs. Field operational testing is widely recognised as an effective instrument to test new transport technologies in the real world. Previous experience in Europe, US, and Japan has shown that field trials are an excellent way to raise awareness, collect real data, and enhance the take-up of ICT solutions. Field Operational Tests have also proved to be a powerful tool for gaining insight into the way new functions and systems suit the user when operated in the real context, and for a sufficient long time to have statistically sound data.

In Europe, such testing has traditionally been carried out at national level, but there is now a growing need to incorporate these tests into a common European framework. The challenge is to promote the use of a common methodology for such testing, so that the results can be shared and compared at both European and national level.

The most progressed FOT EU-project on cooperative systems is SIM-TD in Germany, mainly triggered by the German car industry with field test planned in 2\textsuperscript{nd} half of 2010. SIM-TD as the first big FOT with some hundred cars and infrastructure systems will generate major practical test results, available in ~ 2011.

4.2. EUROPEAN Market Conditions

A future working EU-ITS-system for C2X will use the potential of ~ +15 million new car registrations per year and an annual share from the existing 250 million old cars. Another smaller share comes from the necessary infrastructure.

Car, truck and PTW industry already started considerations for suitable business cases:

\begin{itemize}
  \item The system is completely new, so the classical top down approach for the definition of suitable business plans will NOT work.
  \item The functionality is no argument from start as long as no standardized, widespread implementation amongst all car manufacturers.
  \item To secure momentum a quite large number of cars must be equipped already from the moment of C2X start.
\end{itemize}
For all vehicle types, the category and the segments being most likely to be equipped, at least initially, with some SAFESPOT applications are typically the ones of the high-end models. This is a natural condition, always present when introducing new vehicle systems and devices, since the costs of all new technologies and equipments are almost always high, until the penetration rates become significant and the scale economies allow a larger penetration. Of course the deployment of the SAFESPOT system is targeted towards all categories and segments of all vehicle types (passenger cars, trucks and PTWs), including the low-end ones, where the benefits of the SAFESPOT system find a better exploitation, due to the larger absolute presence of these vehicle categories on the European roads. The deepening of the aspects related to the deployment of the SAFESPOT system can be found in the deliverable D6.7.1 – “The SAFESPOT deployment programme”.

4.2.1. Customer Requirements

As a future working in the EU-ITS, EU car industry is expecting for the future ITS applications of a multi-standard WAVE/WLAN systems, covering IEEE 802.11 a/b/g/p, with p and a/b/g not running at the same time. Major, but basic practical results from FOT will be ready in 2011. Following projects like DRIVE must finally fix the system specs. Therefore MP application in cars is foreseen not before 2013...15 in Europe. However car industry is expecting “real” chips long enough in advance, a realistic time might be in ~ 2012.

4.2.2. Management Highlight

A future working EU-ITS Renesas advocated from 2007 onwards the automotive-spec WAVE system (IEEE 802.11p) and convinced the European car industry and T1 suppliers about the targets for the development of such system. In 2010, a public announcement is going to be made about the first dual band RF chip for WAVE systems. (700MHz for Japanese DSRC and 5.9GHz for EU/US). Further Baseband activities will follow. Renesas is just one of the companies which are qualified to integrate a proper WAVE systems that will be used in mass market as multi-standard solution. Currently stacks and WAVE firmware of all competitors run on
standard PC and make use of standard WLAN components and companies cover in that way current needs for 11p-field test hardware till 2010 or later. Future European market requirement is expected as: a multi-standard system, switchable between WAVE and WLAN. Companies should be ready for mass market by ~ 2012 for earliest MP-use in car-industry after 2013...15. The European WAVE market is +15 million units/year, equivalent to USD 300 million.

4.2.3. Potential Retrofit Solutions

The so called Stand Alone SAFESPOT plug-in, as described before, should be the most probable architecture to support the retrofit introduction in the already circulating vehicles.

It’s possible to imagine that a very thin implementation of the SAFESPOT paradigms, with minimal essential safety applications, supported by an easy and cheaper HMI should find place in order to play the role of enabling factor for the market penetration.

For instance, a V2I communication device with the support of a small computation unit and a simple HMI should be enough to allow the deployment of an application like the Speed Limitation.

Such a solution can be provided by third part aftermarket suppliers but it’s probable that the Car Makers can also act to provide such a custom kit to be easily integrated in the more recent model year car of their own brand.

4.2.4. Standard Shared Solutions

All the features that not take part of the front end visibility for the end users and do not have distinctive added values for the suppliers are potentially candidates for standardization.

The benefit of standardization is obvious: a common solution is the enabling factor for the silicon supplier to provide investment for IC development in a large volumes and this strongly deals with cost reduction and market penetration.

Standardization acts in the development process model till what we’ve called Step 0 as represented in the following figure:
Standardization may be pushed by legislation/regulation but may take place also as what is normally called “standard de facto”, so the most used solution that can be applied as a general one.

In any case, furthermore, inside each Car Maker/Supplier entity or group, as normally happen today for other aspects of the vehicle design, there are great possibilities to define a common platform design to be shared between different brands and vehicles types.
5. Supporting measures

The main innovation of SAFESPOT Integrated Project is the definition and development of a co-operative system, involving all the actors of the road traffic (vehicles, roadside infrastructure, etc.) to improve road safety. The contribution given includes also significant horizontal activities, liaisons and relevant supporting and coordination measures such as:

- Requirements for availability of radio spectrum;
- COMeSafety Task Force on Common European Architecture;
- Interoperability and conformance testing;
- Cooperative Mobility deployment coordination;
- Liaison with Car2Car Communication Consortium and other relevant organisations;
- Input to standardisation.

Such an approach is especially relevant, due to the fact that the enabling technologies (and particularly the communication technologies for vehicle-vehicle-infrastructure communications) have just appeared on the technological market, and most of them need further developments to meet the requirements set by the safety applications addressed by SAFESPOT.

This results in a lack of standardization, which is a crucial issue, when considering co-operative systems. As a matter of fact, standardization is necessary on two sides. Firstly, the communication systems and, secondly, basic active safety applications have to be standardized to ensure interoperability between all vehicles and with the road side infrastructures. For example, if an accident happens, it does not matter of which brand the car is. Important is only that all vehicles which may be affected by this accident can receive, decode and understand the message and can react properly (by informing the driver in a fast and accurate way).

Regarding the communication technology, in Europe the body which is working out specifications and taking into account European regulations, infrastructures, driving behaviour and government policies is the Car2Car Communication Consortium (C2C-CC).

The C2C-CC currently includes the car manufacturers Audi AG, BMW AG, Daimler AG, FIAT, Renault and Volkswagen and accounts therefore for more than the half of the vehicles built in Europe. Among the objectives of the C2C-CC there is the development of an Europe-wide open industry standard for communications from vehicle-to-vehicle and vehicle-to-roadside and, consequently:

- the preparation of the communication standard based on the developed specifications;
- the observation of current standardization activities and existing standards;
- the presentation of the results to the European standardisation bodies.

Within this approach, for the first step of a frequency band (dedicated to safety applications based upon vehicle-vehicle-infrastructure communications) allocation process, C2C-CC is co-operating with the ETSI ERM TG37 (Intelligent Transport Systems)
Systems) to the elaboration of the relevant (and reference) system standards. The exchange of information and the tight contacts already running allowed submitting the draft proposals on the SAFESPOT LDM and applications to the ECC WG FM. In the last years, also contributions to the standardisation of the communication channel and on the network messages have been provided.

SAFESPOT Integrated Project contributed with its activities and supporting measures to this standardization process by providing the C2C-CC with inputs coming both from technologies oriented subprojects (regarding the communication technology, an important contribution was provided by the SINTECH subproject, addressing the developments and adaptations of innovative technologies, whether made available from recent or running projects or standardisation initiatives like C2C-CC) and the applications oriented subprojects (SCOVA and CoSSIB). The liaisons between SAFESPOT and C2C-CC also allowed to use the existing co-operations with standardization bodies, in order to foster the creation of standards and regulations needed to enable and deploy the addressed safety applications and systems.
6. Exploitation Strategies

6.1. Preparing for pilot projects and field operational tests (FOTs)

The SAFESPOT consortium partners would like to bring cooperative systems closer to deployment by a large scale validation of the cooperative technologies and applications as well as operational/business models.

For this reason, it seems to be very useful to enlarge the experience collected during the SAFESPOT activity and to prepare for Field Operational Tests (FOTs) of close-to-market cooperative applications and services across existing or planned cooperative system test sites.

The Field operational tests will have the following elements:

- build a “Virtual European Cooperative mobility Testbed for Operational validation” by linking existing national and/or project cooperative infrastructure test sites;
- create a virtual programme of trials of common applications & services, using one or more common technology platforms for vehicles and infrastructure, and following a common FOT and assessment methodology;
- validate in a consistent way across Europe the user acceptance, effectiveness and value of a number of cooperative mobility services & applications, that make use of new generation vehicle-infrastructure communication technologies;
- focus on public services for traffic and network management, traveller information and intermodality, and for commercial telematics, fleet management and logistics services.

The services and applications considered in the scope will be generally those that are characterising the cooperative approach, with the specific involvement of both vehicle and infrastructure actors, cooperating for a safer mobility.

6.2. Preparing for a cross-sector cooperative mobility deployment activities

The EU funded project SAFESPOT has made a breakthrough by demonstrating that the cooperative approach is fully applicable to the road safety, with large expected benefits for all of the road users, including the vulnerable ones. Partners from more than 50 European organisations have contributed to the work, either by specifying requirements, developing software, hardware, demonstrator vehicles, sensors and systems for the infrastructures. These achievements have been tested in the project test sites. As a result, the consortium provided systems and applications that are fully in line with the ITS Action Plan published by the European Commission and that will enable large scale field operational tests on cooperative systems, services and applications.

In this regard SAFESPOT cooperates with other relevant IPs, such as CVIS and COOPERS in a joint effort for promoting standards, systems, applications and
platforms for a safe, efficient and environmentally friendly cooperative mobility enabled by vehicle-infrastructure and vehicle-vehicle communication.

This effort is aimed at enabling future deployment of cooperative systems and services to create a structured dialogue in the following areas:

- Cooperative Users: focus on the needs and requirements from a user’s perspective, liabilities, business cases, operational models etc.;
- Test sites: focus on pushing the development from demonstration to deployment by building on the current tests-sites;
- Application Developers: focus on harmonised development of applications that enable pan-European deployment of applications, through the different test-sites. Interoperability is of key concern;
- Core technologies: the enabling technologies for communication, standardisation, protocols, APIs etc.;

6.3. Preparing for promotion of SAFESPOT results after project end

During the project’s lifetime, dissemination activities have also played a crucial role within the project in promoting awareness and understanding of the SAFESPOT technologies, systems and applications. These dissemination activities included demonstrations at the test sites (including worldwide relevance events such as the Stockholm ITS 2009 and the Amsterdam Showcase 2010) together with workshops based on websites, newsletters, flyers and brochures. The contribution of press releases, articles and other means such as visual and audio products, videos, webcasts, “podcasts” etc., mass broadcast media (TV, radio) were another effective means of dissemination.

In order to make cooperative systems a household name and generate bottom-up demand for relevant products, the different stakeholders involved need to have a clear and common understanding of the benefits that such systems can bring them. Moreover, they have communicated the SAFESPOT achievements and benefits to a public beyond the project consortium. This was a joint creative effort from various stakeholders in activities across the project.

The Coordinator CRF, together with ICCS, who has acted as a SAFESPOT Dissemination Manager (DM), was responsible for managing and coordinating these overall SAFESPOT dissemination activities during the project lifetime. To achieve the SAFESPOT long term objectives, all involved stakeholders should cooperate to achieve an optimal and sustainable use of the transport means. The activities of strict relevance for the cooperative mobility should address mainly:

- Vehicle-to-Vehicle, Vehicle-to-Infrastructure communication: connect vehicles with each other and link vehicles with nearby roadside equipment and transport infrastructure;
- Cooperative monitoring: provide real-time vehicle-based data about road, traffic and environment status and incidents.
• Cooperative safety applications: provide local hazard alerts, the safe intersection, and wrong-way driver warning.

• Cooperative traffic management: use vehicles as “virtual loop detectors”, provide vehicle-traffic control interaction for smooth driving.

Although SAFESPOT will continue to use the same printed materials such as flyers, brochures, the principal channel for communication will be the public website www.safespot-eu.org, which will remain active to provide a read access to the:

• public deliverables,

• papers & presentations and

• other publications (e.g. press articles, brochures, flyers, etc).

Moreover, to reach professional and general public audiences beyond the SAFESPOT consortium, videos, webcasts, “podcasts” etc., as well as mass broadcast media (TV, radio) will remain downloadable to bring the work to a wide audience and give a strong modern image to all dissemination activities.

Furthermore, when marketing the SAFESPOT technologies, systems and applications, there are various target audiences to be considered, and the marketing objectives will vary for each audience. Target groups could be distinguished to:

• “decision-makers”, in order to be aware of the capabilities and benefits of the SAFESPOT achievements)

• end users (educate users on the services being deployed and how they can realize the maximum benefits from those technologies)

• the “implementers and operators” (public agencies and private sector companies), who actually get the SAFESPOT system implemented and who operate and maintain them once they are in place.

The most effective marketing campaign will be the one tailored to each of the target audiences. Each audience will have different information needs, and the best medium for reaching one group may not be the best for every group. In the short term, not all vehicles and (local) road networks will be equipped with on-board or roadside units respectively. Thus an effective marketing campaign could primarily focus on a SAFESPOT champion test site where already successful implementation of SAFESPOT systems and applications has been achieved. For example, the decision makers at local / municipality level would have to engage to an establishment of an indirect marketing campaign by introducing SAFESPOT system into public transportation through pre-competitive procurement.
7. Conclusion

This final Exploitation plan sets out the partners’ intentions for the exploitation and implementation of the project’s results, both individually and collectively, beyond the end of the project. Communication and dissemination activities are crucial in promoting knowledge sharing, awareness and understanding of the SAFESPOT exploitable developments.

In order to make cooperative systems a household name and generate bottom-up demand for relevant products, the different stakeholders involved need to have a clear and common understanding of the benefits that such systems can bring them.

The present document sets forth the strategies and measures to be employed by the SAFESPOT project in order to prepare for pilot projects and FOT’s, for cross-sector cooperative mobility alliance and last but not least, for the promotion of the SAFESPOT results after the project end.

The present document D8.4.2 – “Technological Implementation Plan” provides a complete and public overview of the exploitation results, together with a (confidential) detailed plan for exploitation or use in further research for the individual exploitable achievements.
8. References


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(this part of the document is confidential)