SARI: AUTOMATIC ROAD CONDITION MONITORING TO PROVIDE INFORMATION TO DRIVERS AND ROAD MANAGERS – TOOLS FOR DIAGNOSIS

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ABSTRACT

The SARI project aims to bring about a significant reduction in the number of accidents by providing drivers with better information about the driving difficulties they will have to confront. The project essentially targets secondary roads.
The objective is to relate a level of risk of loss of control to the characteristics of the road in order to identify information that helps drivers move from normal attention to increased attention and modify their behaviour. The difficulties taken in account by the project are physical discontinuities in the road; deterioration caused by wind and rain; discontinuities in road visibility and legibility.
The research results which can be exploited by the local authorities take the following form:

- 1. tools for diagnosing the road locations with the highest risk as regards loss of control and loss of visibility;
- 2. tools for providing information and warnings about these zones;
- 3. evaluations with regard to the acceptability of the proposed systems to drivers and their possible deployment by road managers.

SARI: ORIGIN AND EXPECTATIONS

Benefit study: sharing of objectives

In order to respond as well as possible to road safety issues, it was decided to favour rural roads which account for more accidents and a greater total length of road (360,000 km). This obliges us to develop low cost diagnosis methods. The support and involvement of local authorities thus became a priority and during the specification phase of the project, when it was given the name of SARI[1] (Automatic Road Condition Monitoring to provide Information to Drivers and Road Managers), many discussions with local authorities allowed us to refine the project's objectives.

The SARI project occupies a remarkable position in PREDIT[2], differing from and complementing the other on-going projects and initiatives. It focuses on the rural road network and aims to transform the infrastructure into a source of data which is appropriate and useful to road users and road managers. It is located at the boundaries between road improvements and driving aids and aims to identify information that gives a more precise

[1] SARI: http://www.sari.prd.fr
[2] PREDIT 3 French Programme for Research and Innovation for Land Transport 2002-2007

description of driving conditions in order to supplement current signing. The driver will then be provided with an appropriate message about the instantaneous state of the road. Although on-board signing is an eventual possibility, it was decided that the project would initially test roadside data that is accessible to all drivers.

The architecture of the project: the position of the partners

The organization and management of the project have been determined by three major considerations:

- output should be produced in the short and medium terms which, in view of the duration of PREDIT 3, means that some must be timed for late 2008;
- strong involvement on the part of the local authorities that manage county roads;
- a multidisciplinary approach: socioeconomic studies, accident studies, technological developments, observations on roads which should demonstrate the technical, economic and legal feasibility of the proposed solutions and their human and social acceptability by drivers. The feasibility of deployment on a larger scale must also be demonstrated.

4 sub-projects have been launched, 3 of which target different sources of loss of control:

- Physical discontinuities[3] in the route in the case of RADARR (Research into Attributes for Early Diagnosis of Road Discontinuity);
- Deteriorations caused by rain and wind in the case of IRCAD (Informing road users about the risk of discontinuities in the route due to poor weather)
- Discontinuities in visibility and understanding of the road in the case of VIZIR (Intelligent vision of risky roads and zones).

The fourth sub-project, AJISE (Acceptability in legal terms, to individuals and society and from the economic standpoint), has a cross-cutting and methodological role, particularly with regard to the trials.
Work on RADARR and IRCAD started at the beginning of 2005 and on AJISE and VIZIR at the beginning of 2006.
SARI's entire budget is approximately €14.5 M, including €4 M of subsidies.

THE SARI PROJECT: CONTENT

SARI aims to improve:

- Our knowledge about driver and vehicle behaviours with regard to the difficulties encountered on the road;
- Techniques for identifying and characterizing these difficulties (trajectory and vehicle observation stations and diagnosis methods);
- New information or guidance systems to warn drivers about the hazardous nature of the driving situation.

The effectiveness of the information and guidance systems is evaluated by on-road trials in three French Départements.

The work for the **SARI/RADARR** theme (Research into Attributes for Early Diagnosis of Road Discontinuities) involves setting up a system on bends and at intersections that warns

[3] Discontinuity: when the level deteriorates from a normal state to a degraded state in a sudden or imperceptible way.

drivers at the appropriate instant of a risk that they may lose control of their vehicle. The risk in question is that related to the characteristics of the infrastructure. The function developed in this way describes risk on the bend and will be compared to the results of accident studies. The final design for the diagnosis vehicles will be proposed on the basis of cost and a comparison with current measurement tools.

The **SARI/IRCAD** theme (Informing road users about the risk of discontinuities in the route due to poor weather) is complementary to the previous one and deals with the risk of a sudden deterioration of skid resistance as a result of rain, which may be aggravated by wind.
The diagnosis of the route is based on a determination of the traffic speeds which are compatible with the skid resistance. Two approaches are implemented:

- a "road-centred" approach. This determines the safe speed on the basis of the characteristics of the road using models that link the weather, the wetness of the carriageway and the skid resistance. Accident analyses which take account of weather conditions are used in combination with this approach in order to establish a risk factor;
- a "vehicle-centred" approach. This uses research conducted in the framework of the ARCOS project, in particular an instrumented vehicle developed by INRETS[4] for the on-board evaluation of skid resistance, and makes use of a study of the dynamic behaviour of vehicles, with the influence of wind, in order to provide information on the risks of an isolated light vehicle becoming unstable.

The **SARI/VIZIR** theme (Intelligent Vision of Risky Zones and Routes) aims to diagnose road visibility and legibility along routes and proposes a variety of information or guidance solutions for drivers in 2 interurban situations: intersections and summits on straight roads. Three specific issues will be covered:

- diagnosis of the geometric visibility of the road (which depends mainly on the layout and masking by vegetation and constructions: Figure 2), and of night-time visibility (which depends principally on the contrast between the carriageway and the obstacles that need to be detected). These tools are derived from existing equipment and are based on image processing techniques and vision models;
- at intersections with a poor level of visibility of legibility, informing drivers on the priority road about a potentially risky situation on the non-priority road;
- improving the legibility of summits on straight roads and gaining a better understanding of the factors that cause accidents; the objective is to assess operational devices which improve visual guidance and therefore vehicle trajectory (both on-site and with a driving simulator).

The cross-cutting theme **SARI/AJISE** (Acceptability in legal terms, to individuals and society and from the economic standpoint) aims to evaluate (or help to evaluate) the acceptability of the SARI solutions emerging from the conclusions of the three above themes according to their respective targets, and to ensure methodological consistency between the trials.

Acceptability for users will be assessed with regard to two aspects:

- individual acceptability: how are the messages provided by the infrastructure perceived from the ergonomic standpoint of perception and assimilation of the signal?

[4] INRETS: French National Institute for Transport and Safety Research

- social acceptability: the effects of the type of information provided by the system on the value ascribed to the user and the way the devices affect judgments concerning user responsibility,

In order for the proposed solutions to be implemented, their conditions of deployment must be acceptable to road managers, particularly in terms of:

- legal acceptability: are the messages compatible with legal practices or will they require the legislation to be amended?
- economic acceptability: is it financially acceptable to implement the solutions, do they provide sufficient long-term guarantees while at the same time being able to evolve technologically while retaining the same functional objective ?

LOCAL AUTHORITY INVOLVEMENT AND EXPECTATIONS

The expectations of local authorities and the goals of the project

Accidents on rural roads account for approximately 70% of all road deaths, and this figure has remained stable in recent years. Of these deaths, more than 80% are directly linked to a trajectory control failure.
Although driver behaviour always plays a role in this loss of control, it may have been partly determined by the characteristics of the road which may either trigger an accident or increase its severity.
The SARI project thus aims to bring about a significant reduction in this type of accidents by identifying risk functions which links the behaviour of the driver and the concept of "discontinuity in the route" by giving drivers an appropriate warning message, and, finally, by ensuring that the road and the difficulties it may cause, are more legible and more foreseeable.
Ultimately, the concerns of SARI in terms of the context, goals and stakes are shared by local authorities in their road management role. The research, even though it is intended to be exploited on all rural roads, will be preferentially applied on the county road network.

In particular, the involvement of the Département General Councils in SARI relates to the following major objectives:

- improving road safety, particularly on rural roads, which are characteristic of the county network;
- playing a role in innovative programmes and promoting the emergence of new technologies that assist the Départements in their role;
- entering into public-private research partnerships;
- putting into practice genuine collaboration between the state Scientific and Technical Network and the local authorities;
- being a source of proposals by linking fundamental research, applied research, the acceptability of systems, the terms of deployment and the dissemination of results.

Trials: the content and the choice of sites

This phase, which is at the core of the SARI project, is essential as it presents an opportunity to perform full-scale tests of the information systems that have been developed as a result of the research. It serves as a basis for the appraisal of the devices and their possible deployment on a larger scale. Finally, it provides a way of measuring their acceptance by drivers (impressions) and how they modify driver behaviour (effectiveness).

The local authorities involved in SARI have undertaken a rigorous analysis of the potential sites, based on precise ranked criteria.
They have thus provided a framework for setting up the trials with reference to the following criteria:

- choice of site on the basis of appropriateness with regard to the project goals, constraints in terms of equipment and implementation, requirements with regard to the behavioural evaluation of drivers, specific constraints, with regard to the representativeness of the site (characteristics, traffic, accidents) and regarding perception of the route.
- conditions for the trial on the basis of a precise schedule, the safety of road users and laboratory staff on site, the regulatory framework
- the evaluation phase with regard to the effectiveness of the system, acceptability to users, the cost calculated on the basis of large-scale implementation, manufacturing and distribution potential, measurement of the obsolescence of the technologies used, legal responsibilities.

Anticipated application of the results by local authorities

The research results which can be exploited by the local authorities take the following form:

- 1. tools for diagnosing the road locations with the highest risk as regards loss of control;
- 2. tools for providing information and warnings about these zones;
- 3. evaluations with regard to the acceptability of the proposed systems to drivers and their possible deployment by road managers.

DIAGNOSIS TOOLS FOR RISKY AREAS LOCALIZATION

Each of the themes proposes methods and equipment for diagnosing the road factors which most influence the risk of loss of control:

- for RADARR these involve road layout;
- for IRCAD these involve loss of skid resistance
- for VIZIR these involve loss of visibility.

These methods enable the most sensitive zones to be ranked.

We will present three examples of diagnosis tools:

- 1. Along the road: evaluation of geometrical visibility related to road shape, vegetation and obstacles (buildings);
- 2. In junction: presence detection of vehicles on the secondary road;
- 3. In bend: knowledge of the road use by vehicles thanks to the trajectories observation station.

1. Evaluation of geometrical visibility related to road shape, vegetation and obstacles

To estimate automatically the geometrical visibility range along a route, on inter-urban roads; the measured indicator is strictly related to the shape of the road and the presence of occluding objects in its close surroundings. Three kinds of approaches were developed:

- Estimation with a single camera. First, road segmentation is performed using Parzen-windowing of Lab colour feature space with an original update procedure that allows coping with heterogeneously paved-roads, shadows and reflections, observed under various and changing lighting conditions. Second, visibility is estimated based on the

flat world assumption using a new region-fitting iterative least squares algorithm, derived from half-quadratic theory and able to cope with vanishing-point estimation [5];

- Estimation with stereovision. The flat world assumption of the previous approach is replaced by an estimation of the road height profile obtained by a multiple matching registration algorithm derived from half-quadratic theory [6];
- Estimation with 2D laser. A 2D rotating laser mounted vertically on the acquiring vehicle, a GPS, and inertia sensors are used to build the 3D model of the road and of its surrounding. Then different algorithms are proposed to estimate the geometrical visibility range, according to state-of-the-art definitions (figure 1);

The automatic estimation of the geometrical visibility range along a route is particularly useful to check the adequacy of speed limits.

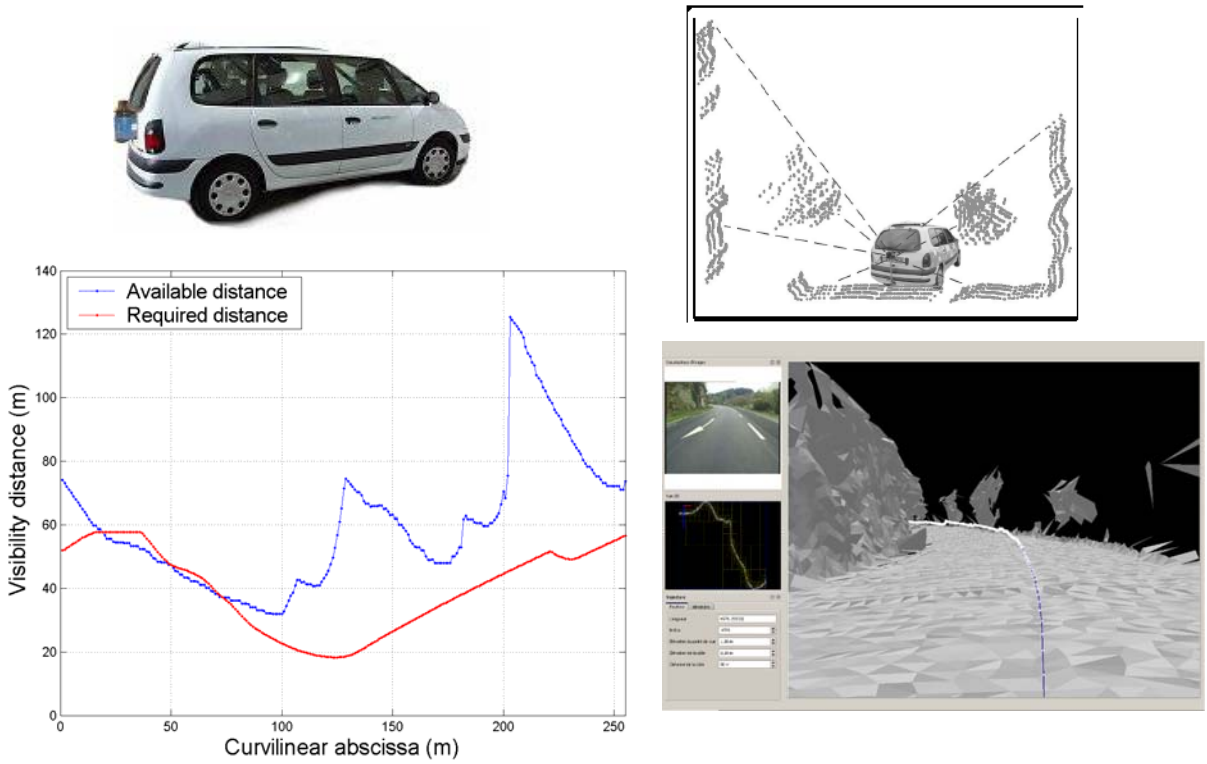

Figure 1 : vehicle and method to measure and calculate the available visibility distance along the road

2. Vehicle detection and tracking system around crossroads

Thanks to a CCD camera, it is possible to analyze the traffic in crossroads (figure 2). This analysis permit to evaluate:

- Crossroads and road lanes modeling
- User detection on the roads
- User localization on the roads
- User type identification
- User speed classification.

The video capture system is composed by fish-eyes lens, day and night CCD camera with IP link, mounted on a pantilt base, IR spotlight, computer and capture software.

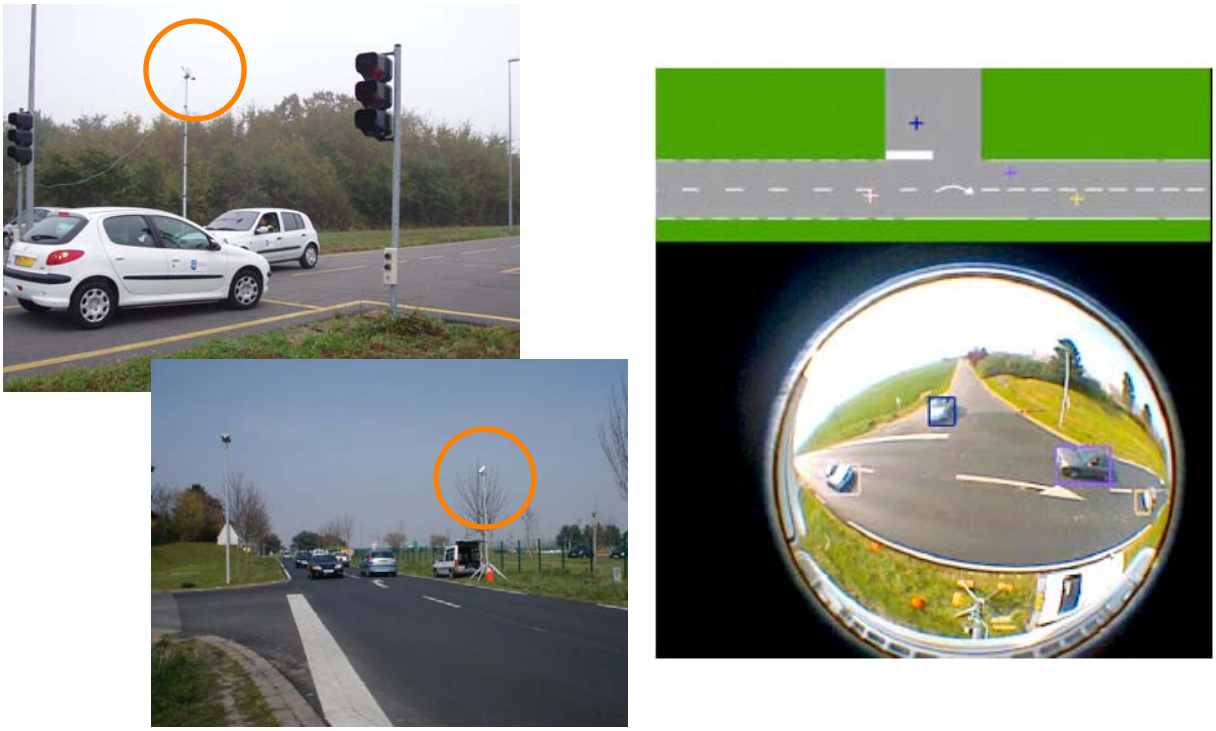

Figure 2: camera system installed on one of the experimental road site

3. Trajectories observation station

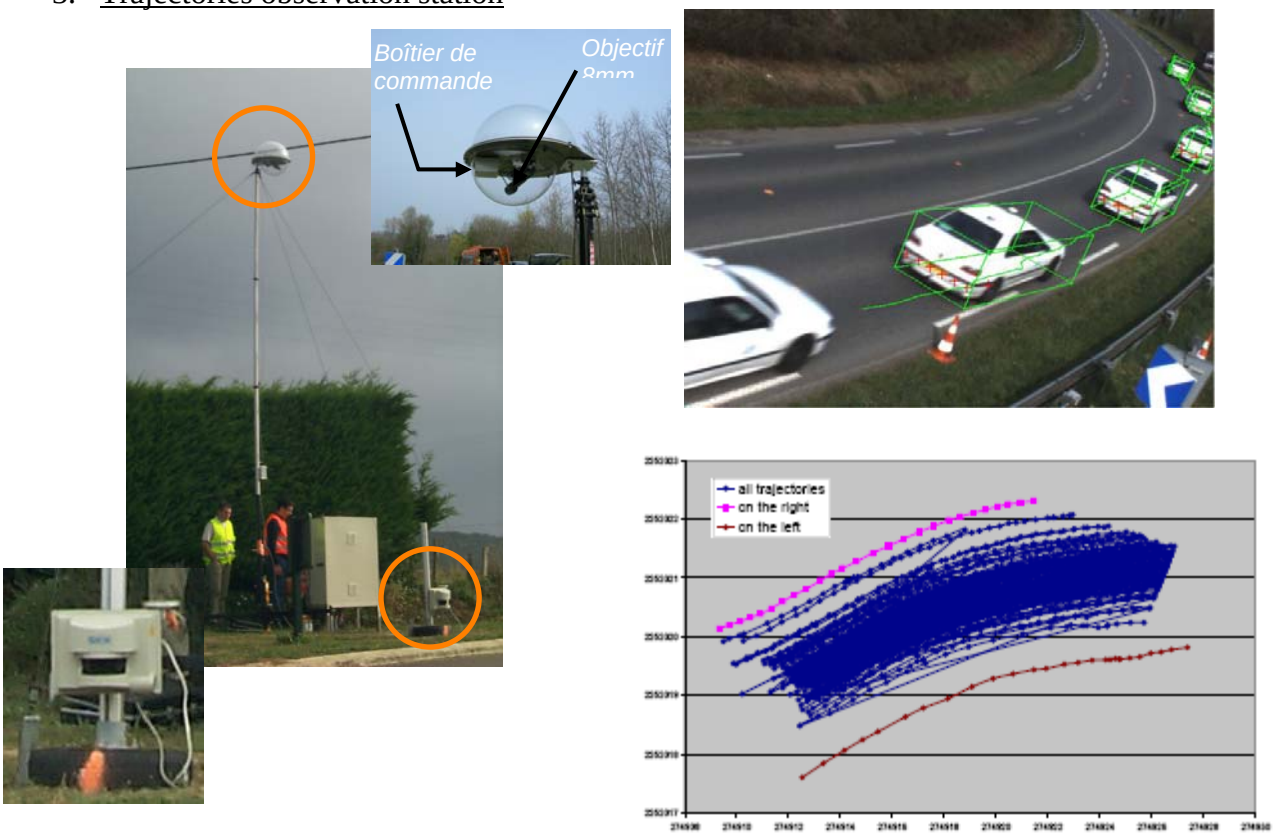

Figure 3: trajectory observation station which consists of a camera and a laser rangefinder, installed on one of the experimental road sites

However, in order to provide a firmer basis for the diagnosis, a method that assesses the trajectories of all the vehicles as they pass through the zone will be proposed using a trajectory observation station. This will provide a means of analyzing the percentage of "suspect" trajectories and assessing a rate of accident risk for the observation period.
This observation station (figure 3) should also allow us to ascertain the causes of local malfunctions and link them to the characteristics of the infrastructure, thereby providing a reliable automatic diagnosis tool with a view to implementing appropriate road safety improvements.

CONTRIBUTION OF THE SARI PROJECT WITH REGARD TO THE EXPECTATIONS OF ROAD MANAGERS AND THE RELEVANT SCIENTIFIC COMMUNITY

In the SARI research project, the infrastructure is placed at the centre of the driver-vehicle-infrastructure system. The tools and equipment that are developed and evaluated will make it possible to measure how much the road contributes to a risk of loss of control. The diagnosis methods which are implemented and the automatic observations of vehicles in specific zones (bends, intersections, and summits) will make it possible to propose new signs and evaluate their effect on drivers.

As the trialled solutions are intended for rural roads, which are characteristic of the county network, partnership with the Département General Councils has naturally been given priority, and it is today both effective and efficient. While the current idea is for the driver information to be presented by the infrastructure using "low cost" devices, the possibility of displaying it inside vehicles is being studied.

The SARI project got under way in early 2005 and is an important stage for our understanding of the influence of roads on driver behaviour. Conducting and analyzing observations of vehicle trajectories at experimental sites will permit researchers in human and social sciences to evaluate better the way drivers take account of the information they receive.

Obviously, the nature and content of the message that is delivered will also be evaluated. The comparison between the results obtained from the SARI project and what is already known and what will be learnt from the SAFEMAP project in which in-vehicle information is provided should be interesting and innovative. New prospects for road signing should be opened up.

Finally, SARI is opening the way for future cooperation between the road and vehicles. The project will investigate the possibility of transmitting and displaying information in vehicles in order to warn drivers more effectively about difficulties on the road.

To conclude, the collaboration and involvement of local authorities in the project in the context of trials on secondary roads is vital. In the longer term, their deployment of the tools and methods produced by SARI in order to meet their specific needs will demonstrate the success of the project.