INNOVATIVE TOOLS AND PRACTICAL METHODS TO IMPROVE THE SAFETY OF THE NATIONAL ROAD NETWORK IN FRANCE

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SUMMARY

The operators of the French national road network improve user safety by designing, operating and maintaining more than 20,000 km of roads. The transposition of European Directive No. 2008/96/EC on road infrastructure safety management is an opportunity to reinforce, complete and promote the four procedures used in France to improve the users' safety.

The article discusses how these approaches are applied in practice, feeds back lessons from their implementation and presents their recent developments in connection with the Directive. Then, an innovative tool for real time collecting of the infrastructure components is presented: ISRI'Cam.
The Road Safety Impact Assessment procedure allows to detect and quantify the safety impacts of the different variants of the project studied, to feed the debate leading to the choice of a variant.
For new roads or those substantially modified, the Road Project Safety Monitoring procedure (in French CSPR) organizes safety audits performed at different study stages of the project, prior to traffic opening, and then after a few months of road operation. On the existing network, the User Safety on the Existing Network procedure (in French SURE) allows to rank the sections of routes depending on their potential gain of safety. On sections with the greatest ranking/potential, a complete diagnosis of the infrastructure (accident analysis, collection of road characteristics data) is made, resulting in an action plan with ex-post assessment.
Since 2009, road safety inspections (in French ISRI) are performed every three years. Specially trained inspectors, not knowing the route and independent of the local road operator, cover the network during day and night. With their "fresh eyes" focus, they detect events of infrastructure connected with safety that daily road operators would no longer perceive.

These procedures, defined in the technical documentation of the Ministry, ensure, on the national road network, a homogeneity in the treatment of the road, a rationalization of the means and therefore an increase in the efficiency of road operators.

Deployed since 2010, ISRI'Cam allows, easily and at low cost, to locate events of the infrastructure, take a photo, record an audio comment and create an inspection report. Many other applications (knowledge of network, mapping of road equipments) are possible with this innovative tool.

1. THE EUROPEAN DIRECTIVE AND ITS IMPLEMENTATION IN FRANCE

The European Directive n°2008/96/EC on road infrastructure safety management [1] gives the basic elements used to implement procedures in order to improve the safety of road infrastructures. Each European Member State should bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 19 December 2010. Member States should also ensure that the technical guidelines are adopted by 19 December 2011.

1.1. Transposition of the Directive in France

The transposition of the EU Directive in France includes a legislative component (a Law) and a regulatory component (Government decrees and Ministry orders). The Law n°2011-12 adopted the 5 January 2011 on various provisions of adapting French legislation to European Union law [2] is the legislative component of the transposition. This transposition will be supplemented by Government decrees and Ministry orders.

This Law introduces the principle to implement four procedures in order to improve the safety of road infrastructures: road safety impact assessment, road safety audits, road safety inspections and the network safety management approach.

1.2. The road network where the EU Directive is implemented.

In the Directive, the four procedures should be implemented on the Trans-European road Network (TREN).

The length of French road network is nearly more than one million kilometres (table 1).

Table 1 – The French road network

Type of network		Length in km
National road network	Network operated by private motorways companies.	Approx. 8,000 km
	Network operated by State local authorities.	Approx. 12,000 km
Counties road network		Approx. 300,000 km
Cities road network		Approx. 700,000 km

The French Government decided to implement the four safety procedures included in the EU Directive on the entire national road network. The length of this network is more than 20,000 km, this network is two times longer than the French road network included in the TREN.

1.3. The national road authorities in charge of the implementation of the EU Directive.

The directorate for transport infrastructures of the ministry for ecology, sustainable development, transports and housing is responsible for the monitoring of the implementation of the EU Directive. In collaboration with the road safety directorate, theses authorities implement the Directive on the entire national road network.

The scientific and technical network of the ministry is responsible for the elaboration of technical guidelines and guides for the four procedures which are the French adaptations of the four main approaches included in the EU Directive.

2. THE SEVEN CRITERIA FOR ROAD SAFETY

The four French procedures to improve road safety are based on a systemic vision of road safety. The three components, road users – vehicles – road infrastructures, interact in a system that is at equilibrium (see figure 1). Road accident reveals a break in the balance.

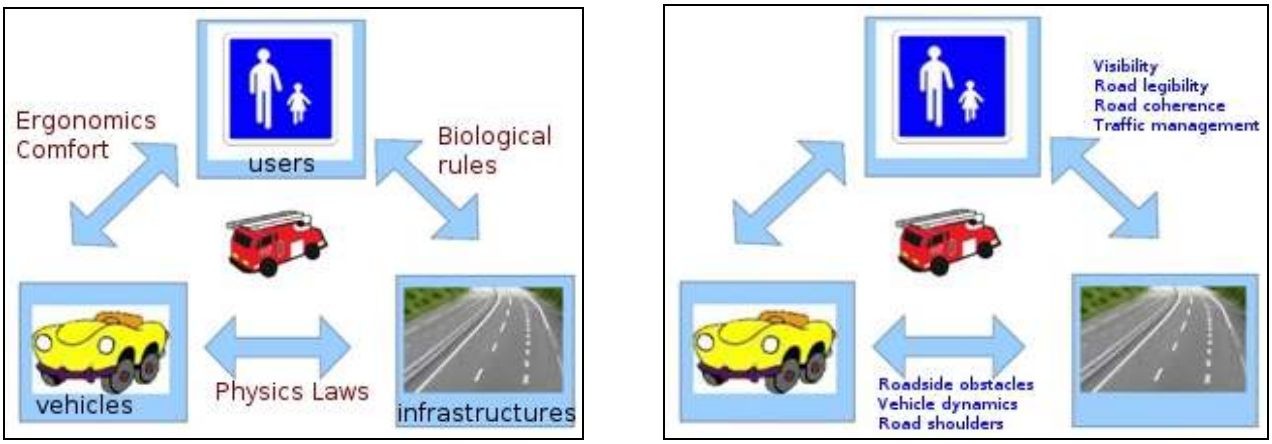

Figure 1 – the system « road users – vehicles – road infrastructures » and the seven criteria for road safety

In order to identify, in terms of road infrastructure, the levers that can be used to improve user safety, seven criteria have been defined [3]. These criteria are presented in this part of the article and are illustrated by pictures taken during road safety audits or road safety inspections on the existing French road network.

2.1. Visibility

Do the road users have enough time (that is to say enough distance) without obstruction, to see an event (for example a car in a junction), a traffic sign or a particular configuration (for example a junction)?

This criterion can be considered like a geometric distance that could be measured. On the left picture, the presence of a junction on a curve can be an issue of visibility between users wishing to turn left and those coming in front. On the right picture, another issue of visibility can exist when a curve is located after a hilltop. In this case, users can not see and thus easily anticipate the change in trajectory and speed required.

Figure 2 – two examples to illustrate an issue of visibility

2.2. Road legibility

Do the information sent by the infrastructure are enough clear and unambiguous to be easily understood by road users?

This criterion can not be easily measured, since it requires taking into account the process of understanding that occurs in the brain of the user, based on information gathered through the eyes of the user. On the left picture, the warning sign « warning: right turn » may be relevant with the curve located 150 meters away, but the information is ambiguous to the user who sees that the next curve is a left curve. The right picture presents a situation where the accumulation of information appearing on the signs prevents the user to easily understand all the posts or at least the most important.

Figure 3 - two examples to illustrate an issue of road legibility

2.3. Vehicle dynamics

Do the road characteristics (crossfall, grip, surface) avoid vehicle dynamic problems (for example skidding)?

This criterion highlights the link between the road infrastructure and vehicles. This is primary road safety that takes place before a loss-of-control accident starts. On the left picture, the bleeding from the surface layer results in decreased grip of the infrastructure. On the right picture, the break in the longitudinal profile is a dynamic issue for vehicles travelling at high-speed (discomfort for motorists, risk of imbalance for motorcyclists).

Figure 4 - two examples to illustrate an issue of vehicle dynamics

2.4. Road shoulders

Can a user, running off the road, takes back control of his vehicle, using road shoulders?

This criterion is also assessing the link between infrastructure and vehicles. This is still the primary security, which takes place before an accident occurs due to loss of vehicle control. On the left picture, the high difference (more than 6 cm) between the road and the verge with a low grip, will not allow the user to take back control of his vehicle in case of loss control. On the right picture, the presence of loose gravels on the shoulder will not promote the recovery of the vehicle in case of loss of control.

Figure 5 - two examples to illustrate an issue of road shoulders

2.5. Obstacles

Are roadside obstacles deleted, or moved, or isolated in order to reduce the consequences of run-off-the-road accidents?

This criterion deals with a major stake of French accidents. Obstacles can be natural (trees, etc.) or artificial (pipe heads, sigh supports, guardrails). For example, a restraint device like metal guardrails will be more aggressive compared to two-wheelers as motorists or users in a truck. On the left picture, trees and pipe heads are very aggressive obstacles. A restraint device is an obstacle for vulnerable users. On the right picture, we can see that the installation of this devices do not meet the technical requirements, including their position relative to the obstacle to isolate and the extremities. The devices in this photo than constitute additional obstacles for road users.

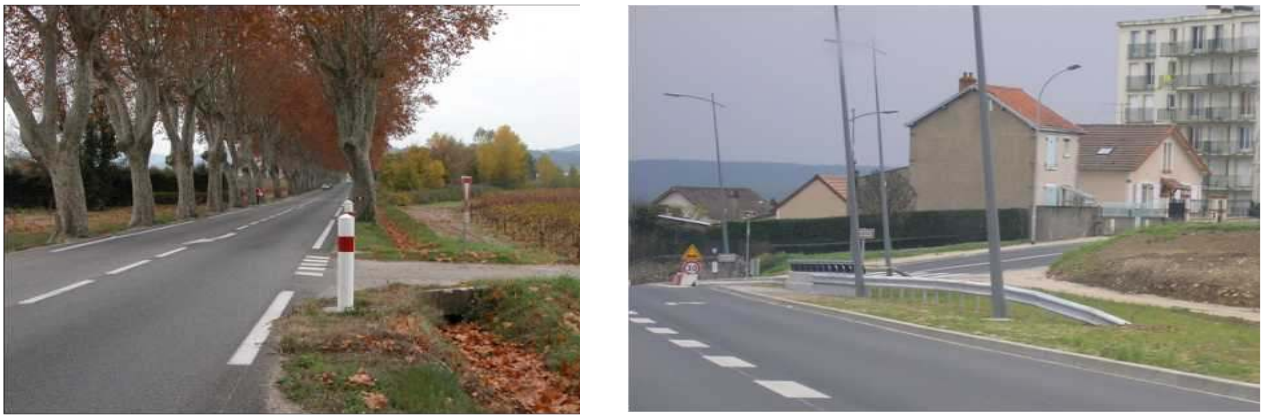

Figure 6 - two examples to illustrate an issue of obstacles

2.6. Road coherence

Are all the road elements (speed limitation, traffic signs, road marking, cross section) coherent with the function of the road?

This criterion can be illustrated by examples of situations where users do not understand the value of the speed restriction signs in place. For the rules are respected, they must appear to be relevant, justified and respectable. In the photo below, there is an inconsistency between on the one hand a limitation of high speed (110 km/h), a cross section inciting speed (divided carriageways) and on the other hand, a road markings indicating the presence of a bike lane, the presence of parking places and pedestrian paths and so users moving at low speed.

Figure 7 - one example to illustrate an issue of road coherence

2.7. Traffic management

Does the road design allow all categories of users to walk, to drive or to ride safely?

The road infrastructure is a public space where different types of users, who move at different speeds, should be able to live. On the left picture, the insufficient width of the sidewalk near a school leads to footpaths on the road. On the right picture, the parking of vehicles on the sidewalk again leads pedestrian paths on the road.

Figure 8 - two examples to illustrate an issue of traffic management

3. THE FOUR COMPLEMENTARY PROCEDURES FOR IMPROVING ROAD SAFETY

In the preceding paragraphs the seven safety criteria that are used to improve the safety of roads in France were presented. This part of the article highlights the complementarity of the four procedures (road safety impact assessment, road safety audits, road safety inspections and the network safety management procedure).

3.1. Four complementary procedures that are formalized

The complementarity of the four procedures to improve road safety lies firstly in the fact that they are implemented at different times during the life of the road.

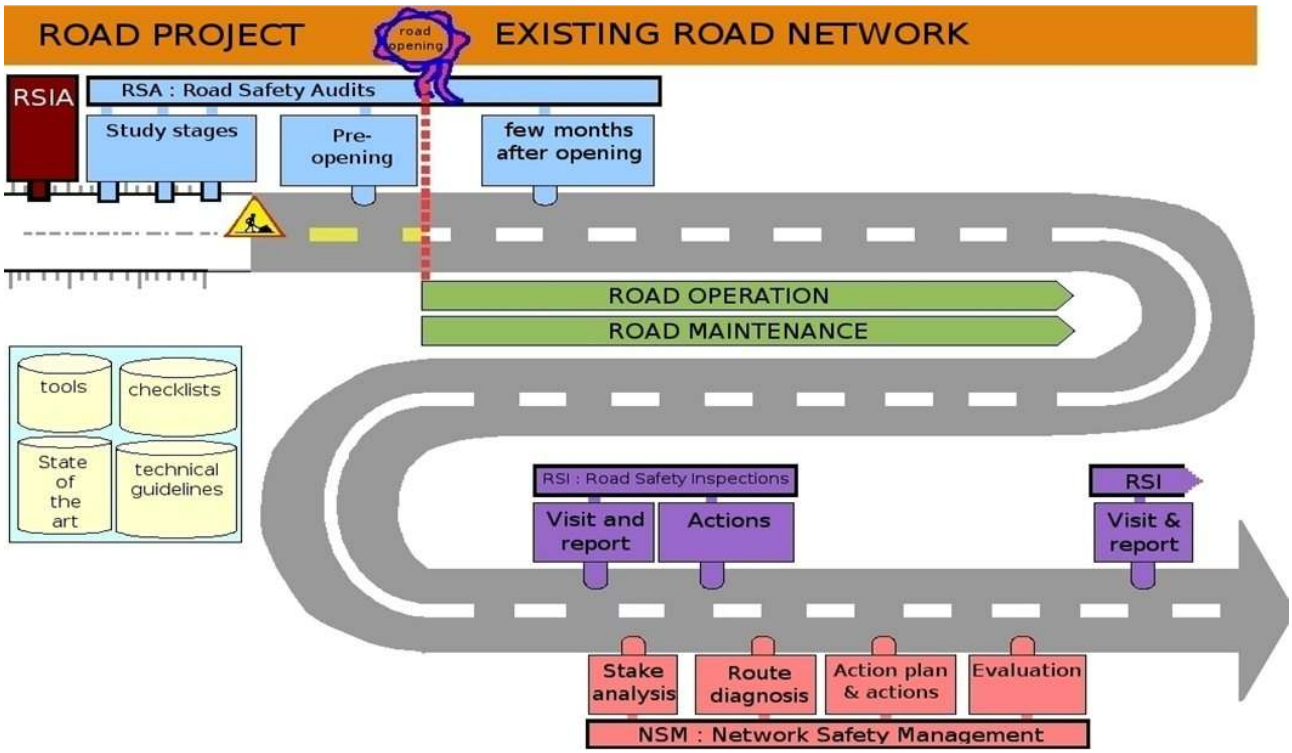

Figure 9 – The four complementary procedures to improve the safety of the roads

At the time of the first studies, road safety impact assessments of road projects give quantified elements to the process of debate and choice of type of road project.

During the design stage and the detailed design stage, road safety audits verify that road safety was taken into account when designing the project. It can then verify that security is guaranteed prior to opening. Finally, it helps to take stock of the first month of operation of the infrastructure (user behavior, incidents and accidents).

On the existing network, road safety inspections allow two inspectors identify deficiencies of infrastructure linked to safety. The local road operators can no longer see these events because of the habits.

Finally, on the existing network, the network safety management procedure, based on accidents that have occurred, optimizes the actions for improving the safety of road infrastructure on the road sections with the highest potential safety gain.

3.2. Road safety impact assessment

What is written in the EU Directive?

« The road safety impact assessment shall indicate the road safety considerations which contribute to the choice of the proposed solution. It shall further provide all relevant information necessary for a cost-benefit analysis of the different options assessed » (EU Directive 2008/96/EC, Article 3).

The procedure implemented in France

<table>
<tr><th colspan="3">Steps</th><th>Tools</th></tr>
<tr><td colspan="3">Definition of the scope of the study</td><td>Traffic study
Territory analysis</td></tr>
<tr><td colspan="3">Calculation of reference indicators</td><td>National and regional indicators calculated from the accident data</td></tr>
<tr><td>Reference Scenario</td><td>Scenario A</td><td>Scenario B</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>Traffic forecasting study for each section</td><td>Traffic forecasting study for each section</td><td>Traffic forecasting study for each section</td><td>Hypothesis on the evolution of traffic values</td></tr>
<tr><td>Accident data modeling</td><td>Accident data modeling</td><td>Accident data modeling</td><td>Hypothesis on the evolution of national and local accident values</td></tr>
<tr><td>Cost of road accidents on expected time</td><td>Cost of road accidents on expected time</td><td>Cost of road accidents on expected time</td><td>Monetization</td></tr>
<tr><td colspan="3" rowspan="2">Synthesis analysis of the safety implications of the different options</td><td></td></tr>
<tr><td></td></tr>
</table>

Figure 10 – The road safety impact assessment procedure

Elements of assessment and specific points to highlight

The definition of the scope of the study is fundamental to the process that will affect the time needed to conduct the study, the complexity of the study or the results. It became necessary to construct a selection criterion for the sections to be included in the study. A criterion based on a variation of the traffic that exceeds a certain value is used.

The calculation of reference indicators (accident rates and densities) may be considered at national level but also at regional level. And by type of section (cross section, urban or rural roads, interchange or at-level junctions) references taking into account local characteristics can be identified.

Developments and prospects

The details of the methodology are being written in a technical guide to be published in 2011. The research work of integrating new safety calculations in the computer modelling tools for traffic forecasting is currently underway.

3.3. Road safety audits

What is written in the EU Directive?

« A road safety audit means an independent detailed systematic and technical safety check relating to the design characteristics of a road infrastructure project and covering all stages from planning to early operation » (EU Directive 2008/96/EC, Article 2).

The procedure implemented in France

Different stages of the road infrastructure		Taking into account the safety	Tools	Role of auditors
Road project	Preliminary design	The Project-team builds the project by filling in the grids. The Road Owner shall establish controls to ensure that the grids are completed.	« Preliminary design stage» audit grids. « Preliminary design stage» technical sheets. Safety repository.	Auditors check if the grids are well completed and study the criteria included in the Safety repository. They write an audit report.
	Detailed design	The Project-team builds the project by filling in the grids. The Road Owner shall establish controls to ensure that the grids are completed.	« Detailed design stage» audit grids. « Detailed design stage» technical sheets. Safety repository.	Auditors check if the grids are well completed and study the criteria included in the Safety repository. They write an audit report.
	Prior to opening		« Prior to opening stage» audit grids. « Prior to opening stage» technical sheets. Safety repository.	Auditors complete the grids and study the criteria included in the Safety repository. They write an audit report.
Infrastructure opened to traffic	During the first year after opening		Grid to interview the local road authority. Incidents and accidents data.	Auditors interview the local road authority and the Police. They go to the road in order to detect safety events.

Figure 11 – The road safety audits procedure

Elements of assessment and specific points to highlight

Over 600 prior-to-opening audits have been completed and are incorporated into a national database. Studies of this database have to take into account the responses of auditors to improve the « prior-to-opening » audit grids.

Developments and prospects

It is intended to qualify the auditors for the various audits, so the potential pool of auditors is more important. New training sessions, especially for auditors in the beginning of operations, will be organized to establish and maintain a sufficient pool. The audit grids, technical sheets and methodological guides [4] [5] and [6], published in its first version in 2003 and 2005 are being updated and will again be published in 2011.

3.4. The network safety management procedure

What is written in the EU Directive?

« Network safety ranking means a method for identifying, analysing and classifying parts of the existing road network according to their potential for safety development and accident cost savings» (EU Directive 2008/96/EC, Article 2).

The procedure implemented in France

Stages of NSM procedure	Goals of the stage	Details of the stage	Data and tools
Stake analysis	Ranking the routes based on their potential safety gain.	Cut routes into sections. Calculation of accident rates and densities. Identification of abnormal risk sections. Identification of sections with abnormal gravity. Calculation of the potential safety gain.	Accident national data with their location. Traffic data. List of road sections. National and regional accident rates and densities.
Route diagnosis and action paths	Identify, on the sections where the potential safety gain is the highest, elements of infrastructure that were involved in accidents.	Accidents analysis. Identifying the elements of infrastructure that were involved in accidents. Study the road characteristics databases.	Police report of accidents. Road characteristic database (realized with high performance device).
Action plan	Building safety objectives and propose infrastructure improvements to achieve these objectives.	Identifying action plan. Building safety objectives to reduce the numbers and the gravity of accidents.	Guidelines on potential gain of road infrastructure actions, elaborated from national and international experiments.
Actions and evaluation	Achieve the safety actions and assess the gains following the implementation of actions.	Implementing a device to measure the behaviour of users (speed, incidents, and accidents).	Traffic data. Accidents data. Data coming from the local road operator.

Figure 12 – The network safety management procedure

Elements of assessment and specific points to highlight

The road sections to be made by the local road authority may be difficult and not without consequences for the calculation of accident rates and densities. The correction of the location of accidents is an essential element in ensuring the accuracy of the study.

Developments and prospects

Since 2011 the stake analysis are updated every three years. An update of the method emphasizes the need to distinguish in the ranking the rural roads to the urban expressways, two rankings are achieved. Technical guides [8] [9], [10] and [11] were published in 2006 and 2007.

3.5. Road safety inspections

What is written in the EU Directive?

« A safety inspection means an ordinary periodical verification of the characteristics and defects that require maintenance work for reasons of safety. » (EU Directive 2008/96/EC, Article 2).

The procedure implemented in France

The road safety inspections (RSI) procedure was launched in France in 2009. The RSI technical guide [7] was published in 2008. One third of the entire national road network is inspected each year.

Stages of RSI procedure	Detailed stage	Stakeholders	Data and tools
Preparation for the inspection	Identify the route sections. Contact the inspectors.	Local road authorities. RSI Inspectors	Initial training of inspectors. Inspections program for 3 years.
Route inspection and writing the report of the inspectors	Daylight inspection, in a car, and after nightlight inspection. Writing the inspectors report.	RSI Inspectors	Car with safety devices (car beacon). Camera, Dictaphone, ISRI'Cam.
Feedback meeting	Meeting organised to show the inspectors report and the safety events they have detected.	Local road authorities. RSI Inspectors	Meeting with the different stakeholders.
Writing the report of the local road authorities	For each safety event reported by inspectors, the road operator gives an answer (fast action, simple action, complex action, new study, etc)	Local road authorities.	The local road operator can go on the road to precise the event detected by the inspectors (measure of the height of the guardrail, measure of the distance between the road and the potential obstacle, etc.).
Road safety actions on infrastructure	Most of actions are simple (change traffic sign, etc.)	Local road authorities.	

Figure 13 – The road safety inspections procedure

Elements of assessment and specific points to highlight

Inspectors do not know the route they inspect, so they are in the position of a user who looks at all elements of infrastructure to guide (including directional signs). However the inspectors are trained to detect the elements of infrastructure that are related to the safety (obstacles, issue of visibility, etc.).

Developments and prospects

The year 2011 will be the third year of deployment; the entire national road network will be inspected. A comprehensive review of the RSI procedure and safety actions will be developed. Exchange with other European countries will continue.

4. ASSESSMENT OF THE IMPLEMENTATION OF ROAD SAFETY INSPECTIONS ON THE FRENCH NATIONAL ROAD NETWORK

The road safety inspections have been implemented in France since 2009. This part of article presents the results of the deployment of RSI on the national road network operated by the eleven regional directorates for roads (more than 12,000 km).

4.1. Two years of implementation of RSI

Since 2009, 90 inspections were conducted on this network. The average length of an inspected section is 82 km. Visits are two-way traffic, first during day and after during night. So for a 82 km long section, inspectors travel 328 km.

4.2. The inspectors are the most important part of the RSI organization

RSI Inspectors are all part of the national pool of inspectors. They were trained during which they have been briefed on safety issues of road infrastructures (including the seven criteria for road safety, see §1). They conducted a training inspection during their initial training session.

On 01/01/2011, nearly 130 inspectors have been trained for this road network. They belong to half of them in local road operator directorates, and the other half of the regional technical services or other services (driving license inspectors, etc.).

4.3. Some figures about RSI

Since 2009, 7420 km of the national road network operated by the regional directorates for roads (63% of this network). The average length of an inspected section is 82 km..

The average duration of an inspection is generally less than a week. This includes travel to the place of inspection (between ½ day and 1 day), visit (average 4:40 for daylight visit and 3:20 for nightlight visit), the writing of the inspectors' report (between ½ day and 1 day) and the feedback meeting with the local road operators (1/2 day).

The graph (Figure 14) below represents the inspection visit durations depending on the length of the section inspected and distinguish cross sections. It shows that overall the inspection speed is more important for divided carriageway sections, which is consistent with the fact that the speed limits are higher on this type of roads. However, the difference with bidirectional roads is not as important as what might think (because of the difference in speed limits).

On all roads, inspectors run slightly below the speed limit. Nevertheless they drive fast enough not to impede the flow of traffic (including heavy goods vehicles on some sections may not overtake). An inspector who drives the vehicle must ensure the security of the inspection team by adapting its behavior, but it also ensures the safety of all users who move at the time of inspection.

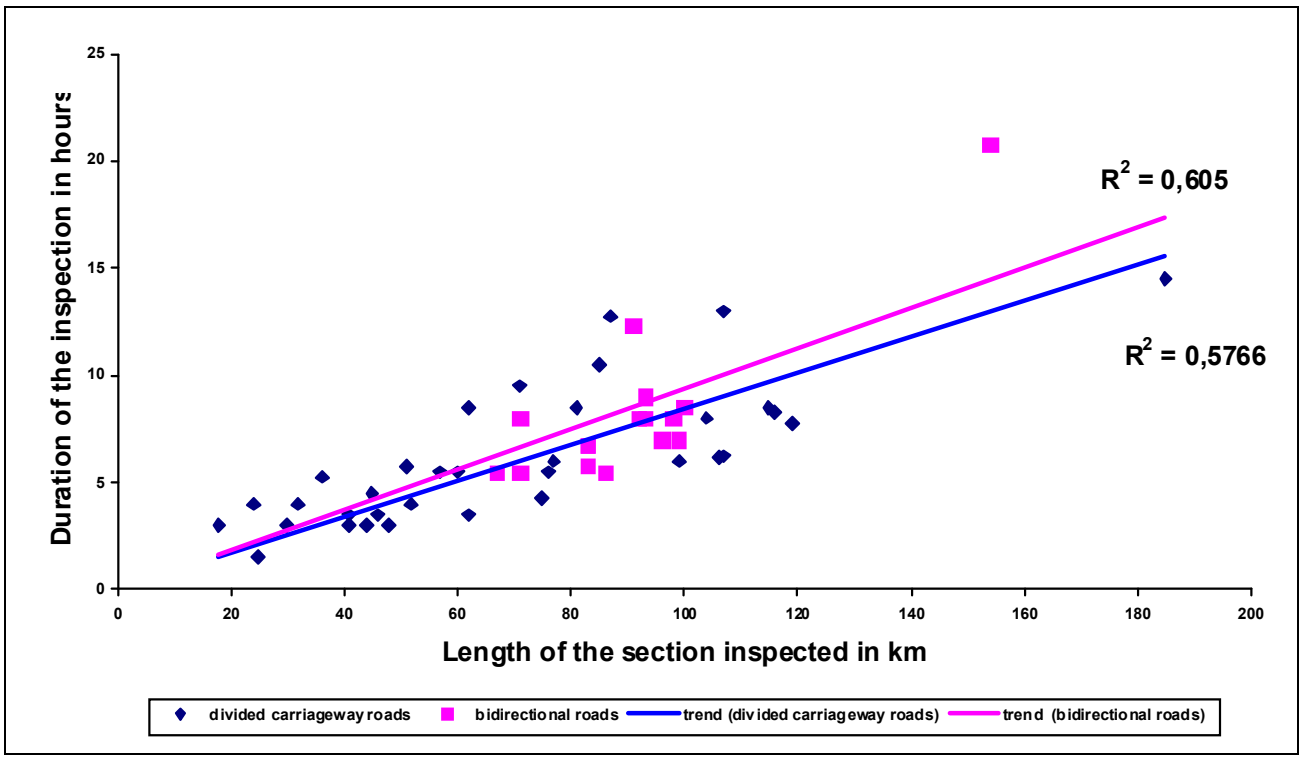

Figure 14 – Duration of inspection depending of the length of the section inspected

4.4. The safety events detected by inspectors

Since inspections began in 2009, nearly 15,000 safety events were reported by inspectors, which correspond to average just over 2 events per kilometer section inspected. Nearly one quarter of events were detected during the night visit, which justifies the methodological choice to impose a night visit. The graph (Figure 15) below represents the number of events identified according to the length of the section inspected and distinguishing cross sections.

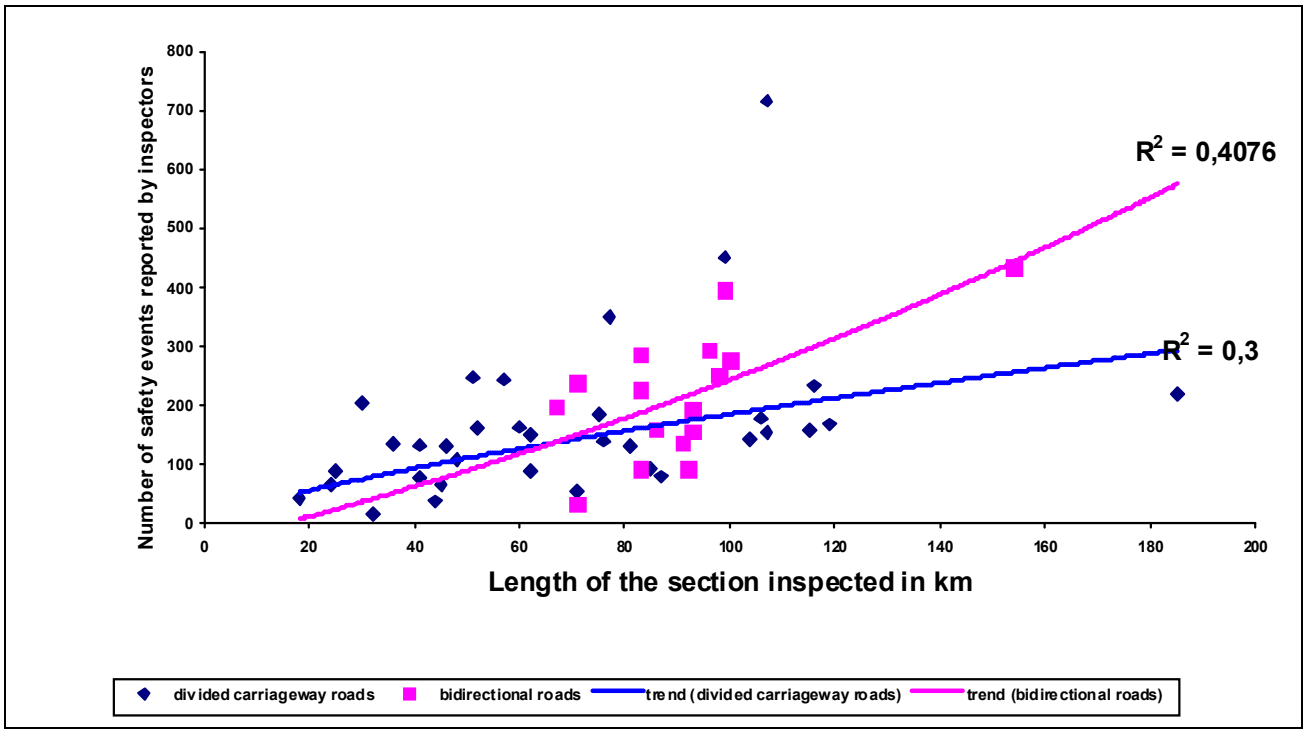

Figure 15 – Number of safety events depending of the length of the section inspected

It shows that the overall number of events detected is higher on a bidirectional road section than on a divided carriageway road section. Some differences are also important to note, however, between different sections of equal length. Different experiences of inspectors or different section characteristics may explain these differences.

The graph (Figure 16) below shows a classification of security events identified by type of road inspected and by safety criterion).

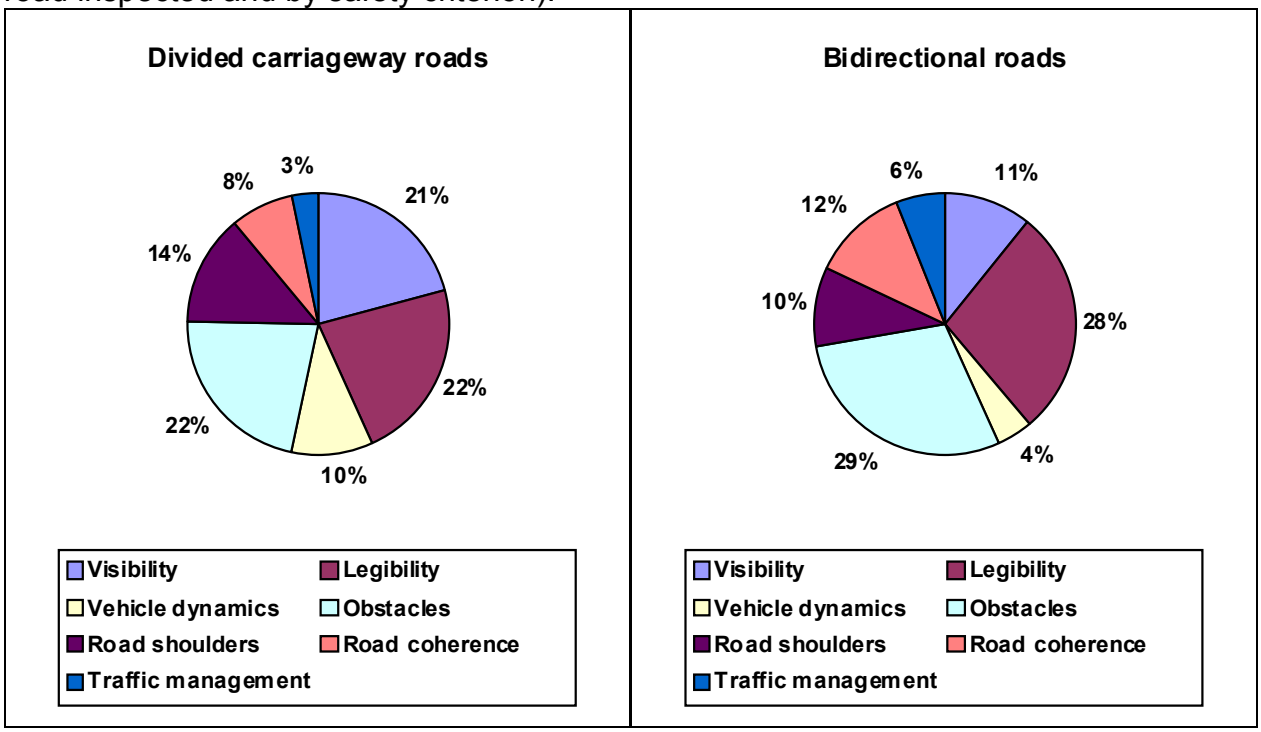

Figure 16 - Classification of safety events by safety criterion and type of roads

It follows that if the proportions are comparable to some extent, differences exist between the divided carriageway roads and bidirectional roads. For example, the criterion "obstacles" (trees, pipe heads) is proportionally higher on bidirectional roads than on divided carriageway roads, as the criterion of "traffic management" (pedestrian paths). In contrast, the criteria "vehicle dynamics" and "visibility" are proportionately more present on divided carriageways roads than on bidirectional roads.

4.5. Answers given by local road operators

Inspectors prepare a visit report; they give the local road operator the inspectors' report at a feedback meeting. The local road authority shall prepare an inspection report in which he indicates the various answers he brings to events identified by the inspectors.

The vast majority of responses are quick and resulting actions are not difficult and are somewhat inexpensive to implement (change traffic sign, mowing of vegetation in front of a sign, etc.). Other events require a second visit realized by the road operator to specify items (measuring the height of a guardrail, the distance between an obstacle and the edge of pavement, etc.). The feedback meeting is an excellent opportunity for exchange and training between the inspectors, the local road operators (patrol officers responsible for the maintenance and operation) and the local road authority.

5. THE ISRI'CAM: A TOOL TO HELP INSPECTORS IN THE RSI PROCEDURE

At the beginning of RSI, the record of events was made by the RSI Inspector sitting in the passenger seat. With a camera and a dictaphone or a notebook, it was difficult and physically demanding to perform this collection (photo taken in manual and audio recording voice recorder and the writing on the notepad). Therefore research towards developing a simple tool to help inspectors led to the creation of ISRI'Cam.

5.1. One goal: to help inspectors

The ISRI'Cam was designed to facilitate the work of detecting and reporting the safety events by the inspectors. Thus, the inspectors, especially the passenger, can focus more effectively on research of safety events, because the reporting is nearly automatic and easy.

5.2. Pragmatism as a requirement

The ISRI'Cam should be usable on all laptops, built quickly (within one year from the initial request and the national deployment), easy to use and cost efficient to purchase and maintain.

5.3. The technical and technological choices

The technical choices were made using commercially available components (camera, GPS receiver, microphone / headphone and power converter) connected to a laptop for simple connections (USB ports). The software programming, the largest value-added technology, was conducted by the Centre for Study and Development of Prototypes of Ministry (CECP Angers).

5.4. The operating principle

When inspectors detect a safety event, the inspector passenger presses the spacebar on the computer. At this time, the GPS position is recorded, a picture is taken, a sound file is created (the inspector recorded an audio commentary). At the end of the inspection, the software automatically creates a "pre-report" in format ISRI, in which are inserted the pictures, the positions of events (calculated by curvilinear abscissa) and a link to the audio file. The inspector has only to write the detail of each event in the report, replaying the audio commentary.

Figure 17 – operating principle of the ISRI'Cam

5.5. Assessment of a year of using the ISRI'Cam

Twenty-five ISRI'Cam were deployed on the national road network operated by the eleven regional directorates for roads. Of the 90 inspections, 43 were with the ISRI'Cam. Usability of the tool has increased by 44% the number of events reported and has doubled the number of photos taken. With GPS tracking, location of events became clear and easy to make. The usability of the tool was highlighted by inspectors.

5.6. Possible uses of the ISRI'Cam for road operators

Road operators have already planned to use this tool to conduct surveys of infrastructure elements (list of road equipment, thematic tours, etc.). The positioning of the events via the GPS also allows use in road databases and geographic information systems. The accuracy of the tool is the accuracy of the GPS system but is still adequate for many applications for road operators.

CONCLUSIONS AND OUTLOOK

The transposition of the European directive 2008/96/CE on road infrastructure safety management into French law is an opportunity to reinforce, complement and enhance the four procedures to improve overall safety currently used in France on the whole national road network. Thus, these pragmatic and complementary procedures allow to design, to put into service and to ensure management of road infrastructure in line with technical knowledge on the topic of road safety.

Innovative tools, such as the ISRI'Cam are developed and used to optimize the implementation of these procedures. They facilitate the collection of data and thus contribute to improving the safety of users with coordinated, technically efficient and economically optimal approaches on the French national road network.

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