

# NETWORK SAFETY MANAGEMENT – FROM CASE STUDY TO APPLICATION

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## ABSTRACT

User behavior is generally seen as the most important source of improvement in terms of road safety. Nevertheless, measures to improve vehicles or roadway infrastructure are still necessary. Studies have revealed that the “infrastructure” factor was present in about 30 to 40% of fatal accidents [6].

This paper aims at presenting and illustrating, by giving concrete examples, a comprehensive road safety method : Network Safety Management (NSM). NSM comprises the first step of a comprehensive safety analysis that enables road administrations to detect sections or itineraries within the network where an improvement of the infrastructure is expected to be highly cost-efficient. Then, these sections can be ranked by their potential savings in accident costs in order to provide a priority list of sections to be treated.

Many countries are seriously engaged in reducing the number of fatalities and casualties on their roads. Improving road safety of the existing network will contribute to reaching this target. For countries having reliable accident data and statistics, NSM can be an important element of a comprehensive and cost efficient safety analysis.

## 1. HISTORY AND AIM OF NETWORK SAFETY MANAGEMENT

The majority of the countries is seriously engaged in reducing the number of fatalities and casualties on the road network. In order to reach this aim all aspects of the transport system – vehicles, road users, and infrastructure – have to be addressed. Accidents are usually caused by deficits in the way these components work together. Therefore, accident data show the combined influence of all components or where these components do not work together well. For road administrations the difficult task is to assess the infrastructure safety of road sections by accident data isolated from other components in order to determine those sections with highest priority for improvements to the infrastructure.

Network Safety Management (NSM) comprises a methodology to analyze existing road networks from the traffic safety point of view. It is based on the German “Guidelines for Safety Analysis of Road Networks (ESN)” which were released in autumn 2003 and the French “User safety on the existing road network (SURE)” approach which was tested by Sétra on 15 pilot routes in 2004. This joint French-German approach was presented for the first time within a working group of the European Commission and it was described in its final report. Then the European Commission adopted NSM together with the management of high-risk road sections as one major element of the currently discussed proposal for a directive on infrastructure safety management next to road safety impact assessment, road safety audits, and road safety inspections.

The aim of NSM is to enable road administrations to:

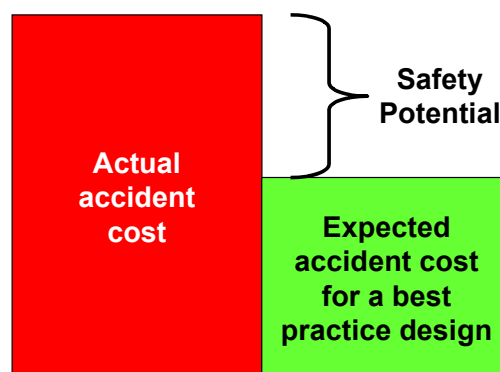
- Determine sections within the road network with a poor safety performance based on accident data and where deficits in road infrastructure have to be suspected and
- Rank the sections by potential savings in accident costs in order to provide a priority list of sections to be treated by road administrations.

Then, the following tasks are to analyze the accident structure of the sections in order to detect abnormal accident patterns which can lead to possible improvement measures, and finally to offer the possibility to compare the costs of improvement measures to the potential savings in accident costs to rank measures by their benefit-cost ratio.

While in France Network Safety Management is understood as a comprehensive process including Black Spot Management, it is in Germany seen as a complementary process.

## 2. ANALYSIS OF ACCIDENT DATA FOR ROAD NETWORKS

In NSM, the key parameter to assess the safety performance of road sections is the so-called safety potential. The safety potential describes the potential savings in accident costs that could be reached by remedial measures. It is defined as the amount of accident costs per kilometer road length that could be reduced if a road section would have a best practice design (Figure 1).



*Figure 1 : Safety Potential*

The advantage of the safety potential compared to the classic accident parameters is that it allows assessing different road types and roads with different volumes at the same time. Furthermore, as the safety potential is given in accident cost, it can be related to the cost of the improvement measures. Since resources are limited, those sections where improvements can be expected to have the highest benefit-cost ratio have to be treated first. The higher the safety potential the more societal benefits can be expected from an improvement of the road.

Accident costs are used instead of accident numbers also because this allows for a weighting of accident numbers by accident severity. Accident costs are usually calculated by multiplying the number of accidents of each category with the related, nationally calculated mean cost per accident. Whenever available, reliable data of less severe accidents for the network under review should be included in the analysis in order to base on all available information and to reach the statistically best possible results. In contrast to this, international accident comparisons (e.g. IRTAD) usually concentrate on a restricted accident population that describes the common basis. Due to different legal basis and

reporting practice, the extent and coverage of national accident databases differs widely between countries. Usually, the more severe the accident the better is the information.

For the analysis it must be aimed at having as long a period under review as possible. The accident occurrence should, however, be as up-to-date as possible so that influences resulting from general trends and changes do not have an impact on the informative value. Experience has shown that a period of 3 to 6 years should be scheduled for an appropriate consideration of the severe injury accidents within the framework of road network evaluations. Due to different traffic volumes and accident numbers on different road types a period of 3 years seems to be appropriate for motorways while a period of 6 years was chosen for smaller German rural roads.

Road sections should be on the one hand as long as possible so that the safety evaluation leads to informative results. On the other hand each section must then be characterized by more or less the same traffic volume, the same cross section and the same type of environment (cross town link or rural section). It is recommended that the section length should be around 10 km (at least 3 km). A pilot project in one German state showed that on rural roads many road sections in German road databases are much shorter. Therefore, different algorithms were tested to aggregate similar road sections. A compromise had to be found between the similarity of the sections and an appropriate section length. Even so, due to the structure of the road network and the number of (longer) cross town links short sections cannot be totally avoided.

In the procedure the actual accident cost per kilometer has to be compared with the expected value for a best practice design. In ideal circumstances this expected accident cost contains no influence of the infrastructure on the accidents any more but represents the accident cost caused only by the other two components of the transport system – vehicle and road users. The best way to estimate the target values would be to calculate the accident cost rate (accident cost per 1 million vehicle-kilometer traveled) for a sample of sections with best practice design. Another possibility would be to use a specific percentile (e.g. 15 %) of the overall distribution of the accident cost rates or even the average accident cost rate (This last solution is the simplest one but will only provide a ranking of sections but no indication of the safety potential if the section is upgraded according to a best practice design). The so-called basic accident cost rate would then have to be multiplied with the annual traffic volume to receive the expected accident cost per kilometer road length.

Statistical tests are recommended to prove the reliability of the results when accident number thresholds are not complied with or severe injury accidents are subdivided into fatal accidents and accidents with seriously injured persons.

Finally, the safety potential is calculated as the difference between the current accident cost per kilometer of the section within the period under review and the expected accident cost per kilometer (see Figure 1). It is also possible to gather the sections into itineraries (so as to keep a homogenous treatment of the itinerary) after having calculated the individual safety potentials. The safety potential of an itinerary is equal to the length-weighted sum of the safety potentials of all the sections that it is composed of.

Then, the sections or itineraries of the road network are ranked on the basis of the magnitude of the safety potential. As a result the ranking of those sections or itineraries in the road network having a particularly high need for improvement and particularly high

improvement potentials is obtained which forms the basis for a detailed study in order to determine possible improvement measures (see Figure 2 and Figure 3).

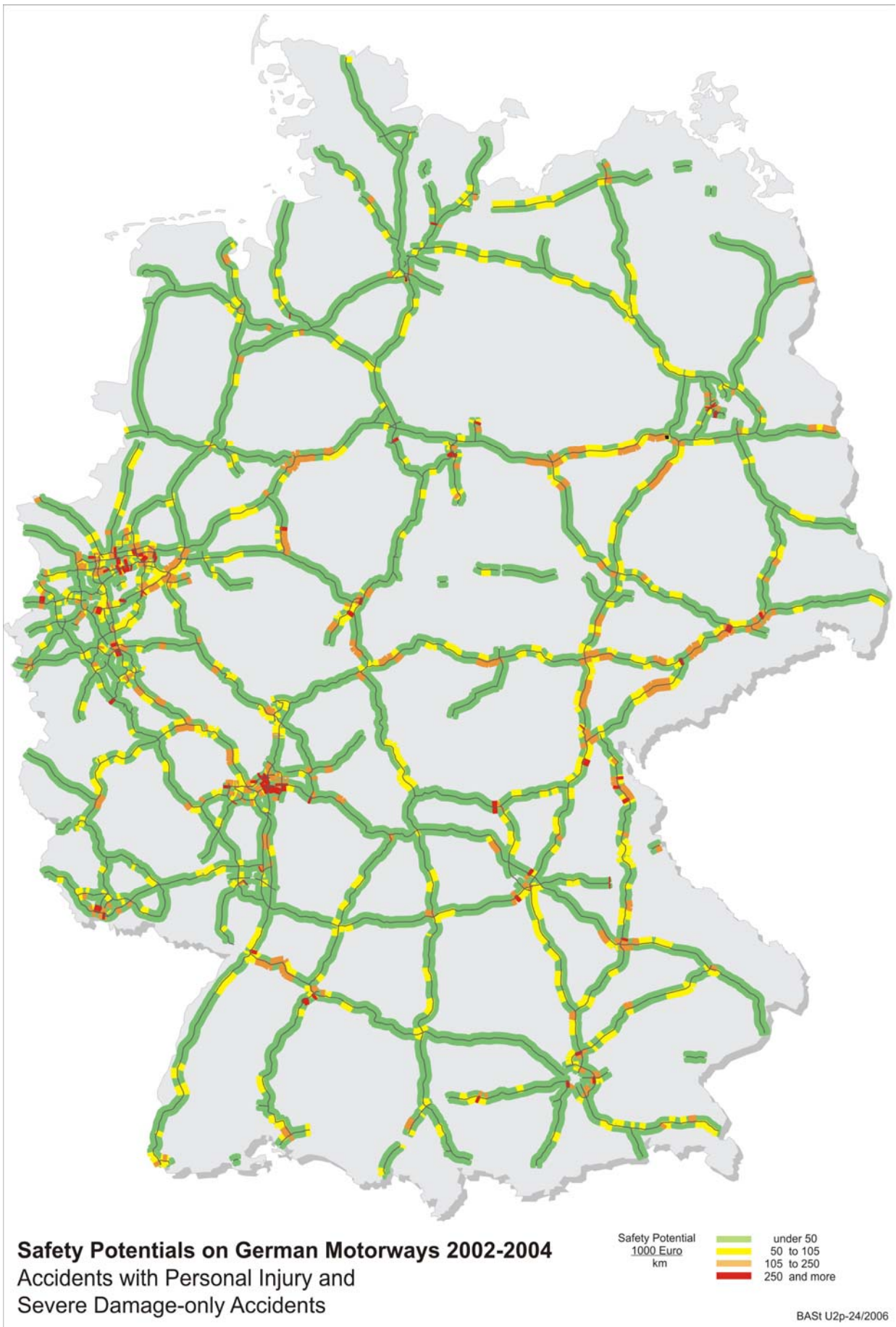


Figure 2 : Map of the German motorway network showing the distribution of safety potentials

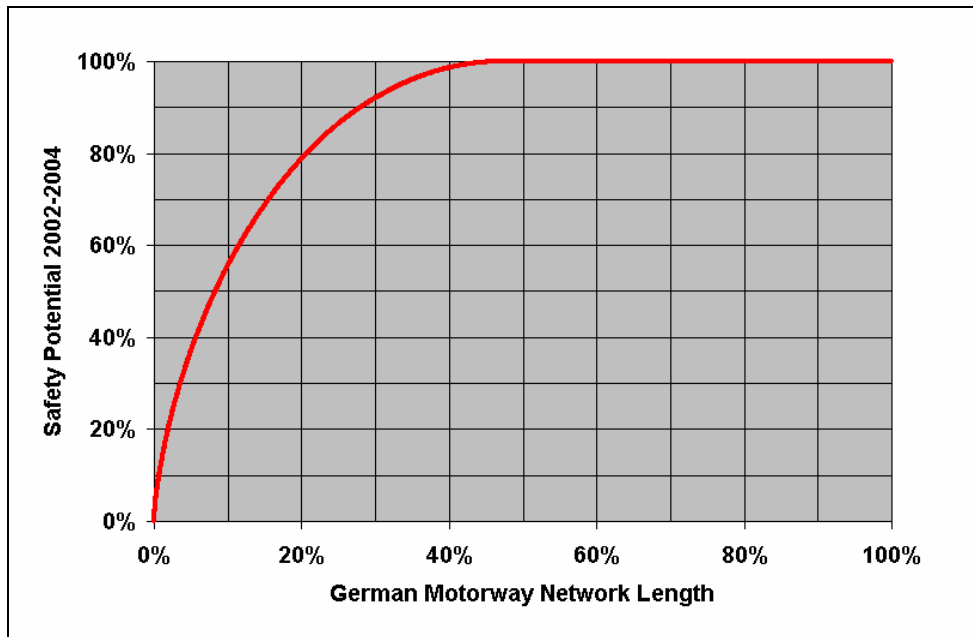


Figure 3 : Chart of road sections with the highest safety potentials within the network under review (example)

### 3. DETAILED ANALYSIS OF INDIVIDUAL SECTIONS OR ITINERARIES

In order to determine suitable measures for road sections or itineraries with huge safety potentials, a detailed analysis of the accident structure should be carried out individually for the specific section or itinerary under review. Therefore, it is advisable to determine conspicuous accident patterns (in the accident structure).

As a further step a comprehensive analysis of the accidents should be performed. This entails an analysis of detailed accident information such as police reports. The dynamic mechanism of each accident can be identified (driving stage, accident stage, emergency stage, collision stage) and accident factors can be determined.

The aim of this analysis is to understand the dysfunctions of the road before implementing countermeasures. It enables planners to adapt solutions to the specific nature of each encountered road and context.

Based on the detected conspicuous accident patterns and on the comprehensive analysis of individual accidents, suitable measures for the improvement of the road infrastructure shall be derived.

Finally, the efficiency of the countermeasures should be assessed. Then it is possible to compare the potential savings in accident costs with costs for countermeasures in order to rank measures by their priority.

### 4. FROM SAFETY POTENTIAL TO MEASURES - A CONCRETE EXAMPLE

A stake analysis has been performed on the national road network of a French county. Sections (usually stretches of about 3 to 10 km, homogeneous in terms of traffic and type

of road) are gathered into itineraries (routes of about 30km) for a homogeneous treatment along the route. The ranking of the itineraries is presented Figure 4.

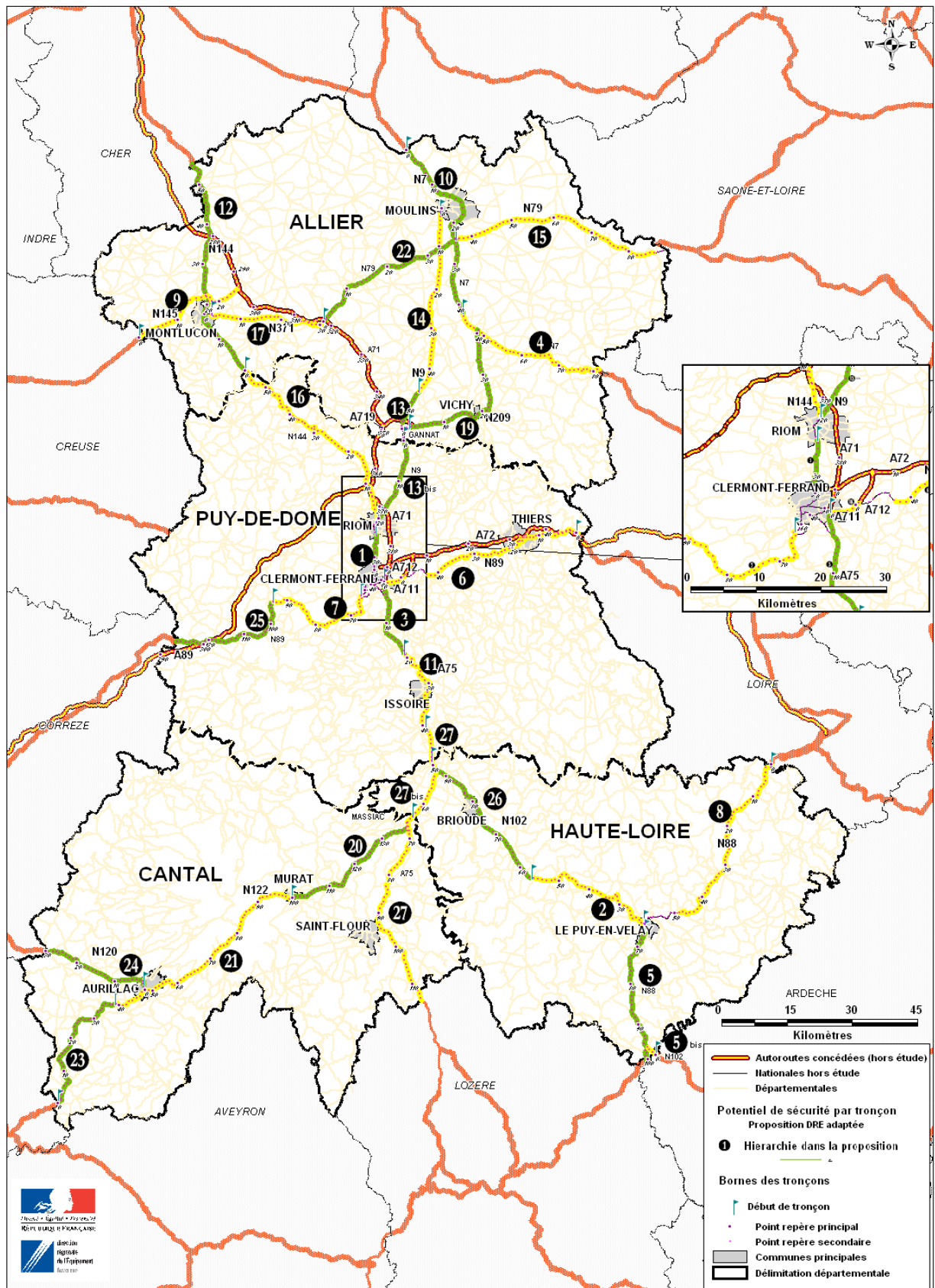


Figure 4 : ranking of the itineraries

As an illustration, a national route from central France will be analyzed. The route is 70km long and comprises two Highland domains, separated by the "col de Fix" (1112 m), as shown in Figure 5.



Figure 5 : RN102

#### 4.1. Stake Analysis

Over 5 years (1998-2002) on 33.6km, there were 97 accidents, from which 49 serious. There was 22 fatalities, 50 seriously injured, and 105 slightly injured.

Figure 6 presents the 3 high-risk road sections as well as the rate and density concerning each section. The average daily traffic is on the 3 sections, respectively, 8700, 4300 and 6800 (vehicle/day).

The route has either 2 or 3 lanes.

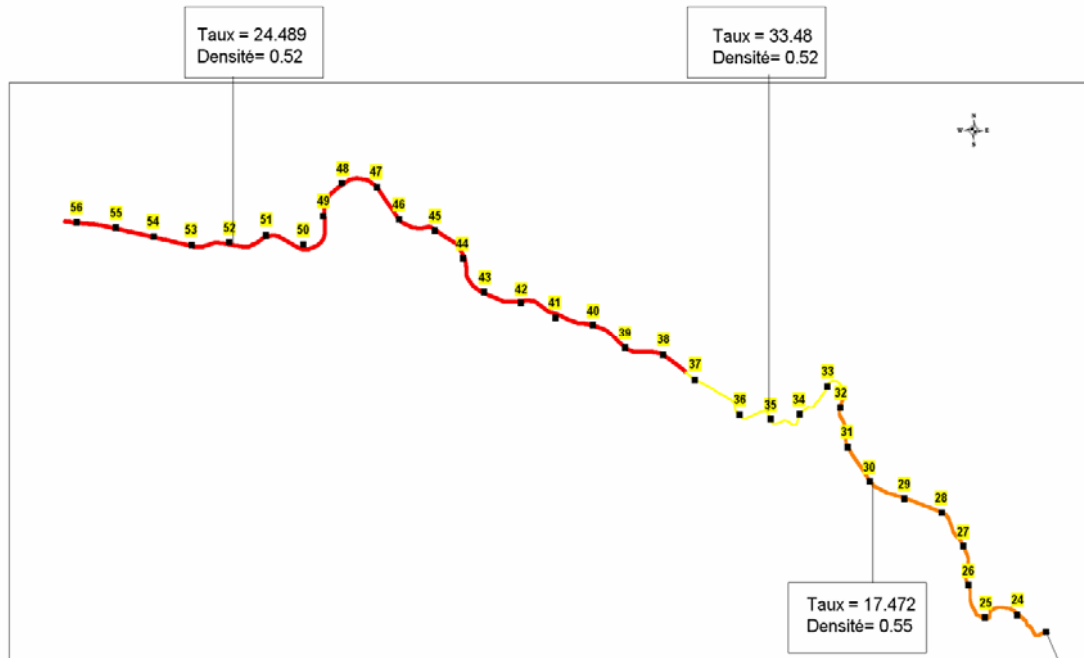


Figure 6 : RN102 Stake analysis

The national references regarding rate and density are :

- Sections 1 and 2; rate = 12, density = 0.35
- Section 3; rate = 9.7, density = 0.43



The stake analysis revealed that the safety potential is about €450 000 for those three sections.

The safety potentials were then aggregated to compare the different itineraries, revealing that the NR102 ranked 2<sup>nd</sup>. The following paragraphs focus on the diagnosis and remedial measures.

#### 4.2. Diagnosis, understanding of the dysfunctions observed

There are 7 high-risk road sections and 3 accident types :

- In curve
- On wet driveway
- In slope

The accidents were regrouped in families (Figure 7) for detailed analysis, and identification of the factors.

4 major accidents scenarios	Accident number (NA)	SI/NA
1 – Loose of control on wet roadway	27	0,74
2 – Junction with a secondary road	14	0,69
3 – Due to a passing/overtaking maneuver	11	0,63
4 – In a curve, on dry roadway	11	1

Figure 7 : Accident families

After further analysis of each scenario (identification of factors...), action guidelines are proposed, as shown in エラー! 参照元が見つかりません。 .

Factors	Nb	Action guidelines
Poor grip in curves w/ Radius < 250 m	14	<u>Cross town</u> : Maintain CTF > 0,5 in curves w/radius < 250m <u>Outside build up areas</u> : Maintain CTF > 0,5 in Chazotte, des Carrières de la Denise et de Pouzols
Poor geometry		According to each location (local clusters)
Poor legibility, excess right of way	4	Check trees alignment and marker posts

Figure 8 : Action guidelines for scenario 1

Local clusters were also identified, and dealt with accordingly. Figure 9 presents a junction, where 5 serious accidents occurred, and the junction was analyzed as accident inducing, especially because of legibility.

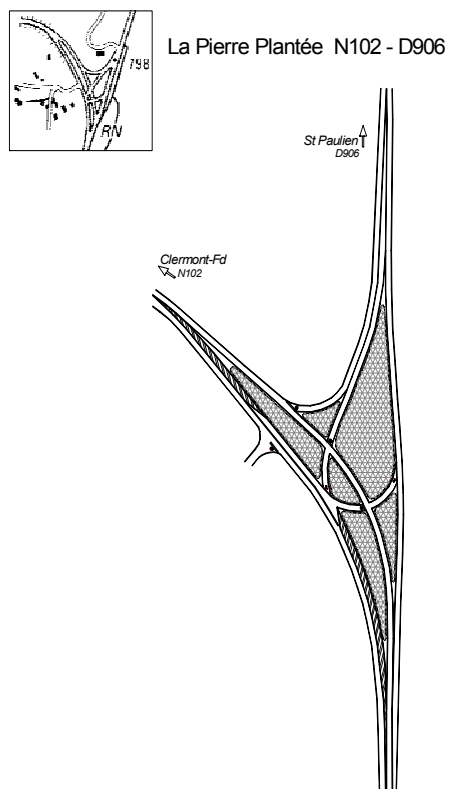


Figure 9 : Poorly legible junction, "La Pierre Plantée" crossing.

After the detailed analysis (accident factors, layout...), action guidelines were proposed (Figure 10).

Factors	Nb	Action guidelines
Complexity – multiple traffic islands	5	Creation of a roundabout
Poor legibility for secondary road use	4	
Poor configuration for right turn (tangential)	4	
Ambiguous marking	1	Modify marking

Figure 10 : Action guidelines for scenario 1

Generally, the following homogeneous action guidelines were proposed along the itinerary:

- Crossings treatment (markings, visibility, adherence, roundabouts, direct lanes suppression)
- Curves treatment (guidance posting, physical separation btw lanes, cross fall)
- Surface replacement taking into account adherence, paved shoulder, overtaking gaps repositioning

- Urban management of cross town links

#### 4.3. Choice, Study and Implementation of the measures

Figure 11 details the treatment of a dangerous crossing:

- Right turn lane suppression
- Private property access suppression
- Marking reconditioning to actual standards
- Traffic island simplification
- Width reduction

The objectives are reduce the frequency of accidents related to family 2 (junction maneuvers) and reduce the gravity on this section.



*Figure 11 : example of crossing treatment*

#### 4.4. Assessment of actions

Great care was taken in assessing the situation before implementing the measures, and a continuous monitoring is planned.

### 5. THE CURRENT PROGRESSES

Since its implementation in France in 2004, the method has been fully deployed on the national road network. Today, all the stake analysis have been performed, some 40 itineraries have been diagnosed, and about 20 million euros have been programmed to finance corrective measures. Discussions will be engaged in order to extend and adapt the method to other types of roads.

In Germany, the safety potentials are now regularly calculated and published for the motorway network by the Federal Highway Research Institute (BAST). For the application on rural roads data problems have still to be solved.

## 6. CONCLUSION

Network Safety Management (NSM) describes a methodology to analyze road networks from the traffic safety point of view and to help the road administrations to detect those sections within the network with the highest safety potential, i.e. where an improvement of the infrastructure is expected to be highly cost efficient. Then, suitable measures can be derived from a comprehensive analysis of the accidents. The safety potential and the calculated cost of the measure form the basis for an economic assessment, which is usually conducted as a benefit-cost analysis.

Therefore, only the described NSM methodology provides all the necessary information for an objective assessment of road safety and an establishment of a ranking of sections for further analysis and treatment. This way, the limited resources are spent in the best way to improve road safety for the whole society.

Many countries are seriously engaged in reducing the number of fatalities and casualties on their roads. Improving road safety of the existing network will contribute to reaching this target. Therefore, Network Safety Management as an important element of a comprehensive safety analysis is a further step in this direction.

## REFERENCES

1. Network Safety Management (NSM) – Final version 08.05.2005 by BASt and Sétra. [http://www.sure.equipement.gouv.fr/IMG/pdf/NSM\\_V\\_FD\\_final\\_cle55ec71-1.pdf](http://www.sure.equipement.gouv.fr/IMG/pdf/NSM_V_FD_final_cle55ec71-1.pdf) or [http://www.bast.de/cln\\_005/nn\\_82230/EN/e-BASt/e-organisation/e-abteilung-v/e-referat-v1/e-sicherheitsanalyse/nsm-long-e\\_templateId=raw\\_property=publicationFile.pdf/nsm-long-e.pdf](http://www.bast.de/cln_005/nn_82230/EN/e-BASt/e-organisation/e-abteilung-v/e-referat-v1/e-sicherheitsanalyse/nsm-long-e_templateId=raw_property=publicationFile.pdf/nsm-long-e.pdf)
2. Guidelines for Safety Analysis of Road Networks (ESN) – Empfehlungen für die Sicherheitsanalyse von Straßennetzen (ESN), FGSV Verlag, Köln, Germany 2003.
3. User Safety on the Existing Road Network (SURE). <http://www.sure.equipement.gouv.fr>
4. Safety Analyses of Road Networks. Federal Highway Research Institute (BASt), 2006. [http://www.bast.de/cln\\_005/nn\\_82230/EN/e-BASt/e-organisation/e-abteilung-v/e-referat-v1/e-sicherheitsanalyse/e-sicherheitsanalyse.html](http://www.bast.de/cln_005/nn_82230/EN/e-BASt/e-organisation/e-abteilung-v/e-referat-v1/e-sicherheitsanalyse/e-sicherheitsanalyse.html)
5. Route-Specific Accident Analyses on Motorways. Federal Highway Research Institute (BASt), 2006. [http://www.bast.de/cln\\_005/nn\\_82220/EN/e-BASt/e-organisation/e-abteilung-u/e-referat-u2/e-analyse/e-analysen.html](http://www.bast.de/cln_005/nn_82220/EN/e-BASt/e-organisation/e-abteilung-u/e-referat-u2/e-analyse/e-analysen.html)
6. Treat, J, et al., *Tri-Level Study of the Causes of Traffic Accidents: Final Report*. Institute for Research in Public Safety, School of Public and Environmental Affairs, DOT HS-034-3-535-77-TAC, March, 1977.
7. Network Safety Management – A French-German Co-operation. Kerstin LEMKE, François GANNEAU, Pascal CHAMBON. TRA2006, Göteborg. <http://www.traconference.com/index.aspx>
8. SURE (Users' Safety on Existing Roads): A NEW METHOD IMPLEMENTED IN FRANCE TO IMPROVE SAFETY ON EXISTING ROADS. François GANNEAU, Pascal CHAMBON. European Transport Conference 2005, Strasbourg. <http://www.aetransport.org/etc2005/>
9. Proposal for a Directive of the European Parliament and of the Council on road infrastructure safety management by the COMMISSION OF THE EUROPEAN COMMUNITIES. [http://ec.europa.eu/transport/roadsafety/infrastructure/safety\\_mgmt\\_en.htm](http://ec.europa.eu/transport/roadsafety/infrastructure/safety_mgmt_en.htm). Brüssel, 2006.
10. Road Infrastructure Safety Management. [http://europa.eu.int/comm/transport/road/roadsafety/roadinfra/reports\\_en.htm](http://europa.eu.int/comm/transport/road/roadsafety/roadinfra/reports_en.htm). European Commission, DG Energy and Transport, High Level Group Road Safety, Brüssel, 2003.

**NB:** Papers 7 and 8 are available at [http://www.sure.equipement.gouv.fr/article.php3?id\\_article=13](http://www.sure.equipement.gouv.fr/article.php3?id_article=13)