Software-based road safety analysis in Germany

Prof. Dr. Ulrich Brannolte
(Germany, Bauhaus University Weimar - BUW, ulrich.brannolte@uni-weimar.de)
Dipl. - Ing. Andre Münch
(Germany, Planung Transport Verkehr AG - PTV, andre.muench@ptv.de)
Dipl. - Ing. Heiko Voß (Germany, Unfallforschung der Versicherer - GDV / UDV, h.voss@gdv.de)

ABSTRACT

According to the IRTAD database, Germany have had the highest number of road accidents with 15,050 fatalities in 1980 (an even higher peak with almost 20,000 fatalities had to be observed before this time period in 1970) and was able to reduce this figure to about 4,467 fatalities in 2008 (over 70% reduction). A comprehensive safety management of road infrastructure becomes more and more important in different countries and on international level; specific software-based tools are decisive elements in such kind of approaches. This paper gives an insight into Germany's analytical road safety work based on the policies and two methods for network safety management applied on macro and micro levels.
In Germany a guideline ESN had been issued in 2003. Its methodology focus on the traffic volume and the severity of accidents within the road network by evaluating the accidents on the basis of accident cost rates. Comparing actual accident-cost density [€/km] with a hypothetical estimated base accident-cost density provides information on the so-called safety potential of road sections. The safety potential is the most important parameter to identify network sections on which safety improvement measures are expected to have the greatest effect. First ESN-mapping results generated with the transportation planning system PTV Vision on the macro level will be shown. Occupancies of road accidents, especially those with serious consequences (injuries or fatalities), are not uniformly distributed among rural or urban road networks and do not correlate with traffic volumes. Mapping of accidents (i.e. locations, types, circumstances, road users, etc.) is an essential prerequisite for drawing sound conclusions concerning accident countermeasures. This applies in particular to accident accumulation sites (black spots). In Germany, road safety experts in police departments and in road authorities use the analytical software based tool EUSKA which represents the micro level.

Key Words : Road safety analysis, road infrastructure safety management, network safety management, black spot management, accident black spot analysis, road inspection

1. Introduction and overview

Road safety analysis procedures contribute significantly to a better understanding of creating safer standards for roads. Recent developments show that because of different reasons software-based tools will become more and more important. Besides, a kind of internationalisation and an assimilation of methods and procedures may be observed, for instance regarding developments in Europe.

A white book on European transport policy published already in 2001 proposes the target of a reduction of the number of road traffic fatalities by 50% in the member states of the European Union. Recently a directive has been published in the official journal of the European Union, that means the member states have to implement special measures on relevant parts of their road networks concerning this target by December 2010.

These accident countermeasures include technical aspects of vehicles as well as behavioural influencing measures and road infrastructure related measures.

This directive for safety management of road infrastructure comprises 13 chapters, in the chapters with numbers 3-6 distinctive procedures as follows are described:

a) evaluation of safety effects of infrastructure projects
b) road safety audit for infrastructure projects
c) safety classifications and safety management in the existing road network
d) safety inspections of roads

It could be strongly expected that these procedures will comprise the kernel of any safety related work for roads in many countries - some details will be given here as follows:

ad a) The aspects of road traffic safety have to be considered in the planning and design process on a strategic level. That means the elaboration and evaluation of potential safety aspects of a planned road. The evaluation requires the possibility to carry out cost-benefit-analyses on the basis of reliable and comprehensive accident data. In Germany procedures had been defined and are in practical use to estimate safety effects quantitatively; these are the guideline EWS [1] and the national Investment plan for traffic infrastructure BVWP [2].

ad b) Further on there is the road safety audit defined as on independent and systematic screening procedure for road design elements to be applied in the different phases of planning up to opening of a road. Road safety audit are in common use in a number of countries but are comparatively new in Germany. After starting in 2002, now there are some hundred especially trained road engineers working as road safety auditors. A specific guideline ESAS [3] describes the German procedures. The requirements for training and professional qualifications for auditors are written down in the leaflet MAZS [4].

ad c) In countries where already a dense road network exists which is almost completed it is obviously important to have a look on different levels on the existing road network because it is evident, that often immense differences occur concerning the reached standard of safety as well as the differences in accident costs in different parts of the network. In specific recent research efforts on traffic safety, concepts for elaborating "safety potentials" on the different categories of roads had been developed. In Germany a specific macro level approach have been established in the guideline ESN [5].
On the micro level a specific analytical tool (named EUSKA) based on sophisticated mapping procedures is in practical use.

ad d) To keep the standard for safety and operability of a road section there is a need of periodical official inspection to recognize defectives. In Germany two approaches have been established, one of this is called "Verkehrsschau" (road safety inspection) which is part of the official German roads traffic regulations (StVO), recently a software-based tool has been developed to fulfil the defined requirements exactly and efficiently. The method is established to find defects on the road side or infrastructure. On the other hand the local road authorities have to check their sections of the road network at regular intervals. This is a process of monitoring the road safety trend on the existing road sections.

All items together present a consistent system of a road infrastructure safety management. A successful application of these procedures for practical use depends strongly on the available data-basis and on the inclusion into user-friendly software solutions - specific applications have been developed in Germany for these purposes, which are described in the following chapters.

The German company PTV was involved to develop applications on both levels of analysis the macro and micro level on behalf of the German Insurers Accident Research (UDV).
The following two examples of road safety analyses, the road network safety management (NSM) and the black spot management (BSM) serve as a model of what also other countries may expect from these solutions for their road infrastructure safety management.
Beginning with the application on the macro level of network safety management, there is a safety classification given by the Working Group on Infrastructure Safety of the European Commission DG Energy and Transport as follows:

...Network Safety Management comprises a methodology to analyse road networks from the traffic safety point of view. It enables road administrations to detect those sections within the network where an improvement of the infrastructure is expected to be highly cost efficient. Indications are given how to determine possible improvement measures. Then, the cost of these measures can be compared with the potential savings in accident costs in order to determine the benefit-cost ratio of the measure for a road section under review...[6]

The necessary methodology for this purpose is applied in the German "Guidelines for Safety Analysis of Road Networks (ESN)" and already also in the French Guideline “User safety on the existing road network (SURE)”

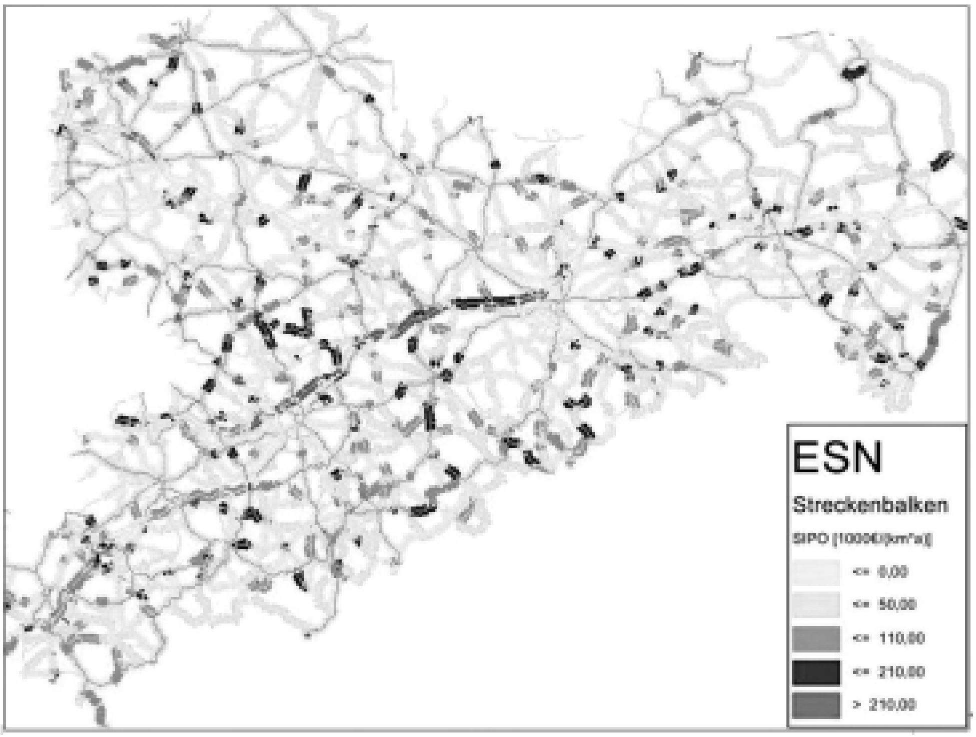
In this context road administrations have the task to assess the infrastructure safety of road sections by accident data isolated from other components in order to determine those sections with highest priority for improvements of the infrastructure.

Following this approach, first of all, sections within the road network have to determined with a poor safety performance based on accident data and where deficits in road infrastructure have to be suspected and to rank these sections by potential savings in accident costs on a regional or national level in order to provide a priority list of sections to be treated by road administrations.

After that, the following tasks are to analyse the accident structure of the sections in order to detect specific accident patterns which can lead to suitable improvement measures and finally to compare the costs of improvement measures to the potential savings in accident costs to rank measures by their benefit-cost.

Network Safety Management comprises therefore much more then often used conventional improvement measures.

Figure 1: ESN results showing categories of safety potentials (German abbreviation: SIPO) on the rural road network in Saxony



2. Safety analysis of road networks

The following approach ESN has to be seen in connection on international basis developed RIPCORD method for safety network analysis [7]

The method in the guideline ESN studies the traffic volume and the severity of the accidents by evaluating the accidents on the basis of accident cost rates; one main feature is to define the safety potential of any regarded road section. An example for ESN-result presentation is shown in figure 1.

The safety potential is the most important decision parameter for road authorities. They aim to identify network sections with high safety potentials on which safety improvement measures are expected to have the greatest effect. The safety potential (called SIPO in Germany) is defined as the amount of accident costs per kilometre road length (cost density) that could be reduced if a road section would have a best practise design [8,9] see figure 2.

Figure 2 : Diagrammatic view on the safety potential defined as the difference between actual accident costs and the assumption of expected basic accident costs refering to best practise road design (source TRA conference paper [8])

The safety analysis is carried out in rural area on motorways, trunk and country roads according to a standardised ESN-method. The ESN-method recommends road sections are divided according to the number and type of accident as well as the network structure. Pilot projects in several German states and cities show that more than 50% of the accidents happen on about 10% of the road network see figure 3.

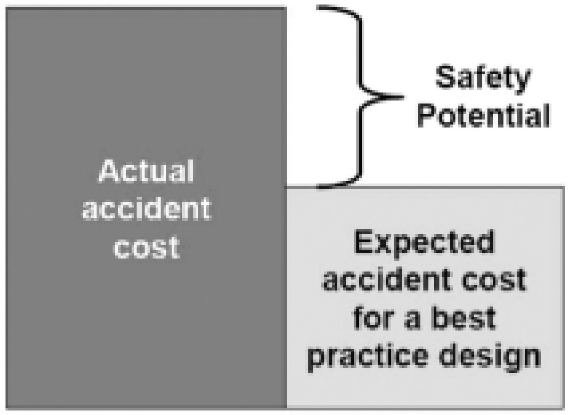


Figure 3: ESN results in Germany show, that more than 50 % of accidents occur only on 10% of the road network

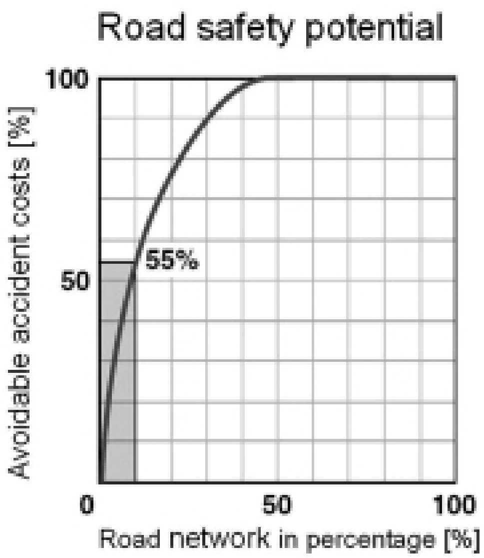
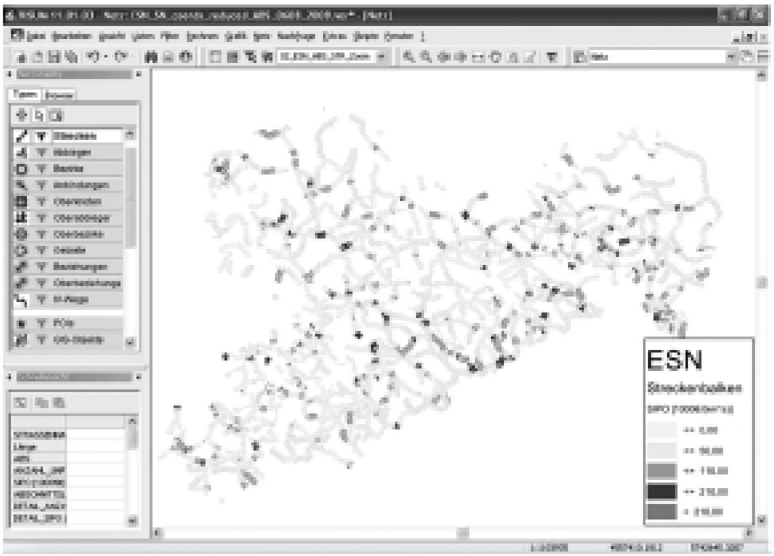


Figure 4 : The ESN application based on VISUM displays road network analysis for country roads in Saxony

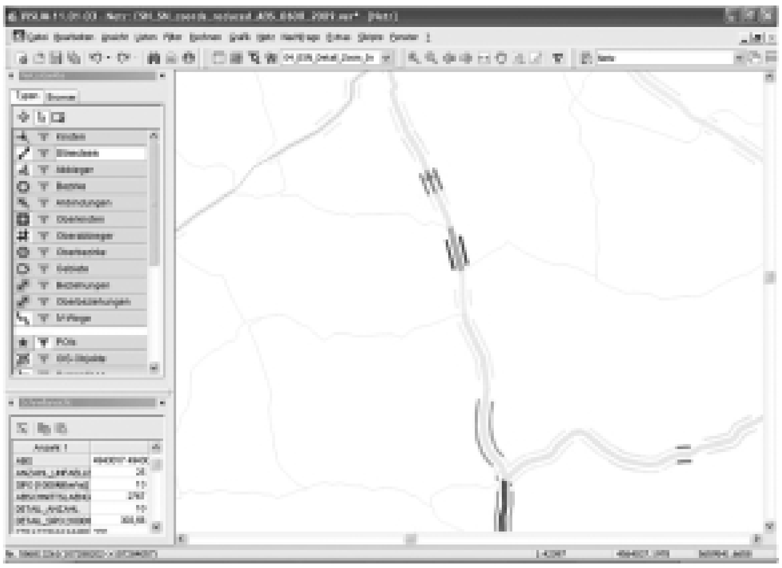


The German Insurers Accident Research (UDV) cooperated with PTV to develop the ESN tool which processes the data and visualises the results in a clear and efficient manner, as briefly shown in the figures 4-9 (VISUM application screenshots). Further requirements include easy and efficient analysis of results and high quality evaluations which provide network-related information about the accident data.

Information about the average workday traffic volumes on the roads where accidents occurred is an important input for the ESN calculations. Therefore, a transportation model for Germany (model type: VALIDATE) was integrated into the ESN calculation process to provide necessary traffic data for the entire main road network of Germany.

The study based on accidents on motorways, trunk and country roads outside of the urban regions was carried out over a period of three years (2004 - 2006). Dividing the road network into road sections in order to represent safety potentials for these sections can be realised on different levels of aggregation. In the cases shown here, all ESN results were based on two different levels of aggregation. The first level covered the road sections of Saxony's state driven official road database to support the strategic policy task and the second level was based on standardised more detailed digitized road network for more operational tasks. In this case a NAVTEQ (www.navteq.com) road network is used.

Figure 5 : The ESN application zoom in with a combination of both levels in the safety network analysis.



The road sections are sorted by their safety performance, enabling users to see where safety issues need to be urgently addressed (figure 6).

Figure 6 : Interaction between table of road sections ranked on their safety potential and displaying of the corresponding road section in the network.

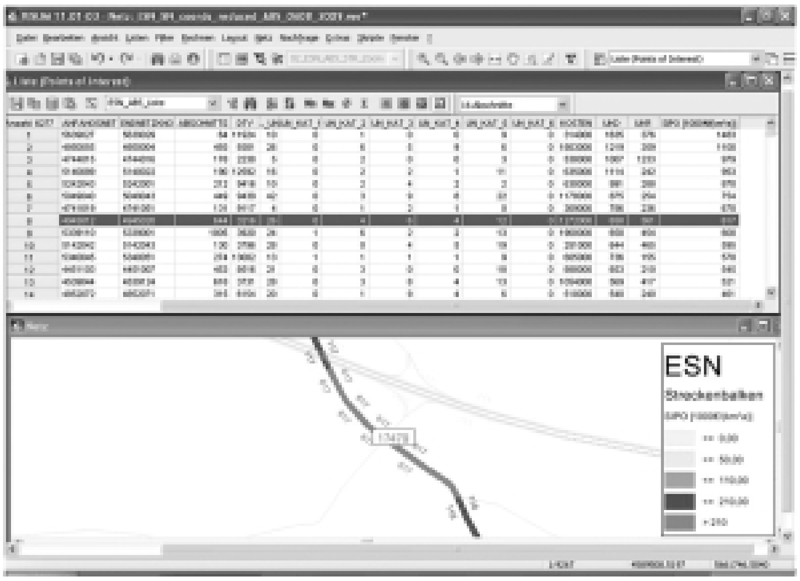
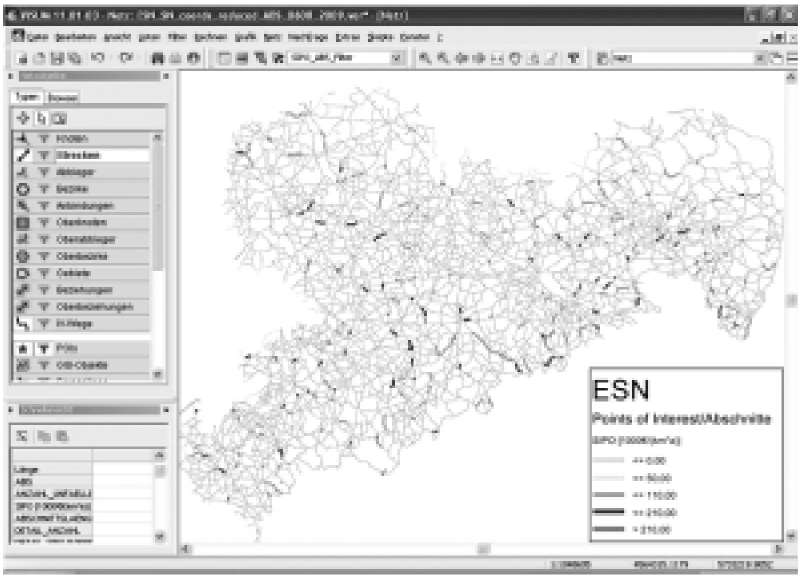


Figure 7 : Filter option on road sections with an safety potential higher than 50 (1000 EUR per km and per year) in the network.



In the meantime the following analysis for the time period 2005-2007 and 2006-2008 had been calculated. It could be demonstrated, that even an automated update process for the ESN-method is well functioning.

The best practise guideline of RIPCORD for BSM and NSM [10] recommends for the dividing process, that the road and traffic based division principles are used. One advantage is, that the principles more or less will result in the same division of the road system for different time periods, which makes it possible to compare the accident level for different time periods for each road section.

The ESN application is developed as an automated process and enables the comparison of results for different time periods, therefore the road sections was divided by the network structure.

The results of the ESN application were displayed and analysed with the PTV Vision software. As this software is designed for planning and analysis purposes of different network scenarios, it can provide helpful information for road safety impact assessment. This allows on a strategic level comparative analysis of the impact of a new road or a substantial modification to the existing network on the safety performance of the road network.

Figure 8 : Example Display Safety potential of an ESN section on a federal road (stratetic level)

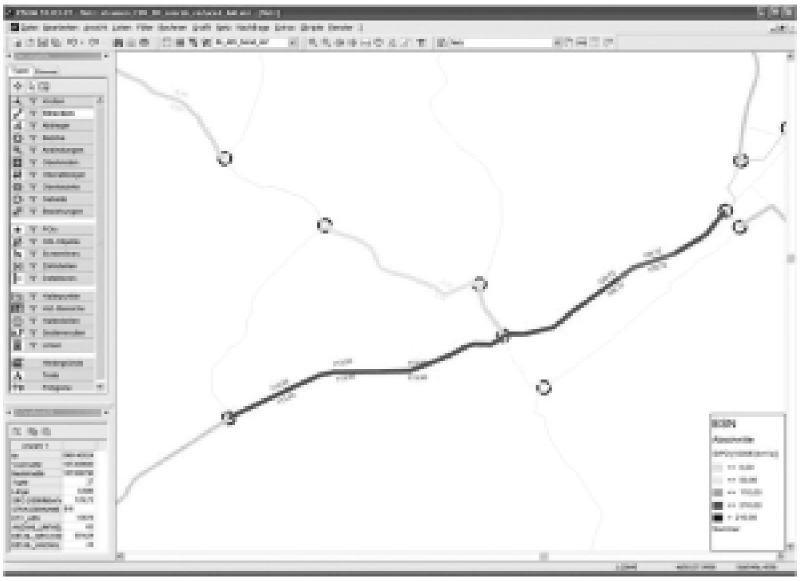
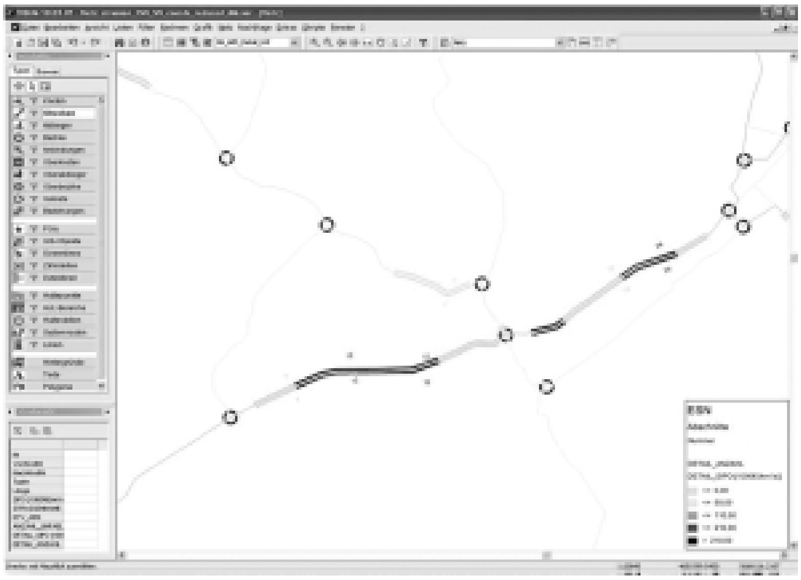


Figure 9 : Example display safety potential on detailed level based on Navteq-segments for operational tasks.



The two levels of aggregation can be displayed together or individually. Users should first look at the route sections on a more aggregated level according to the road construction authority's network structure and then use the detailed view of the road sections for the validation process. Changing the screen view considerably improves the level of detail, so that the safety performance on the different road sections can be estimated on a higher resolution level. The elements of the road, which present a safety concern, can be further on investigated with EUSKA's Local Accident Investigation module.

PTV Vision-based ESN application works as a tool on the very latest professional standard to support road safety efforts on the macro level. The ESN approach can easily be combined with EUSKA application as a tool on the micro level.

3. Safety analysis on the micro level

The Working Group on Infrastructure Safety of the European Commission DG Energy and Transport describes on the micro level about black spot management (BSM):

...The basic approach for black spot identification is characterised by applying statistical analysis and mapping based on the historical accident records of the road network. Therefore accident databases are an essential tool for black spot identification and must contain information on accidents and their localisation on each specific point or road section, including details such as the type and the severity of accident, the vehicles and the road users involved (and weather conditions in the time when accidents occur)...[6]

Figure 10 : Accident mapping with EUSKA of the same part of road network see figure 8 and 9

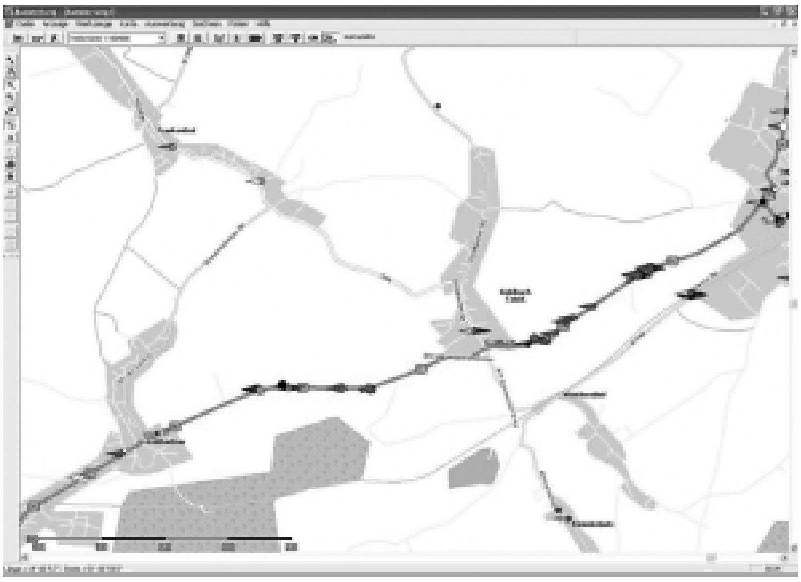
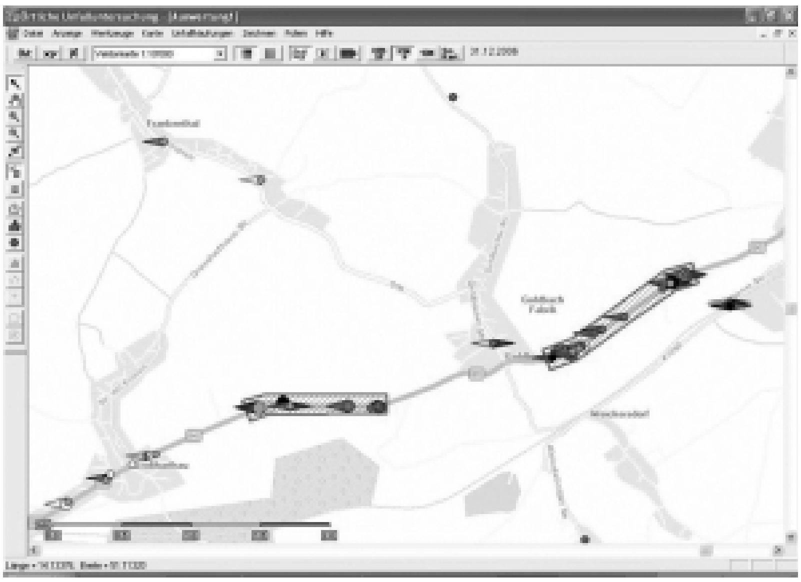


Figure 11: Finding black spots with EUSKA



The German police has the task to collect sets of data from road accidents on the local level just after the occurrence of accidents according to fixed rules and statistical requirements; further more the police departments document accidents on wall-maps, traditionally by using coloured pins for different accidents. These tasks are carried out by following the guidelines (FGSV 2003) [11]. These hand-operated procedures allow rather limited possibilities for in-depth analysis.

The EUSKA software system goes further on in detail analysis it provides numerous analysis options. A particular emphasis is placed on the accident analysis maps used by the police in Germany. These maps display the accidents on a road map over a period of 12 months to focus on concentrations and similarities of accidents. Additionally, there are maps covering a period of three years to record especially severe road accidents with fatalities and injuries which normally occur less frequently and often on other road sections than the accidents without injuries see figure 10. The data is used for local accident investigation in order to identify obvious similarities in the accidents in a particular area. It also supports accident investigation and road safety inspections.

Once black spots have been identified, accident data are analysed in order to find common pattern in accidents see figure 11. A visit of the black spot site is usually part of the process of analysis.

The occurrence of black spots is closely related to the given definitions for black spots, in Germany there are the guidelines FGSV 2001 [12] which are used to identify black spots from stored data sets.

In case the digital accident analysis maps are stored on a notebook, they can easily be used on-site during road safety inspections. The georeferenced accident database provides additional analysis options which go far beyond conventional accident analysis mapping.

The availability of numerous search functions is particularly helpful. All search results can be directly displayed on additional maps on the screen. It is also possible to search systematically for accident patterns in the database. The accident data can be filtered according to almost any recorded accident criteria (in Germany defined by law on accident statistics): for example, all accidents occurring inside urban regions, with bicycles, involving children between 6 and 14 years of age see figure 12. Specific periods of time, such as school start times, or areas like school zones can also be included in the investigation. Additionally, there are almost limitless specific possibilities to search for detailed information on accidents occurring outside urban areas. For example users can thus easily find details of all accidents caused by excessive speed, alcohol or drugs, depending on the age of these people involved in the accident. The new method therefore promotes road safety and may help to change driver behaviour by implementing specific traffic control measures.

Black spot management with EUSKA system includes also a module for analysing accident pattern in detail. In Germany therefore are used the so-called collision diagrams to investigate conflict situations on local spots. Collision diagrams have been proofed as very useful tools for detecting safety deficits easily (see figure 13).

Figure 12 : EUSKA displays accidents with bicycles involving children between 6 and 14 years of age on workdays

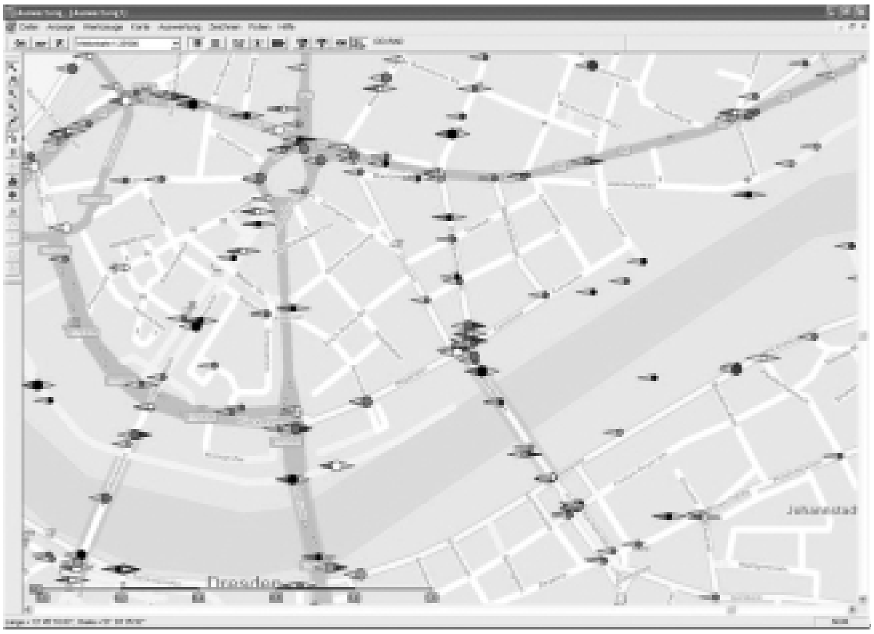
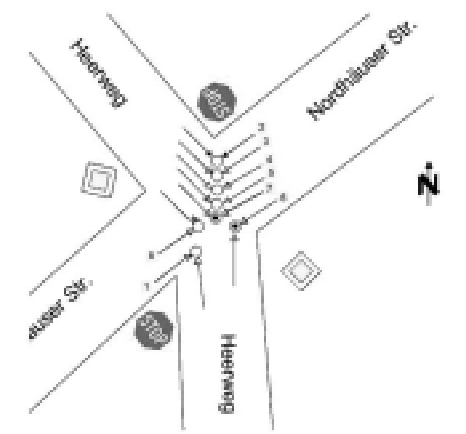


Figure 13 : Collision diagrammes in EUSKA



EUSKA: The collision diagram displays the conflict situation of the accidents in a black spot. The three years collision diagram displays a special accident pattern in this intersection.

The latest development of EUSKA supports an automatic black spot search function. The user defines a few parameters and the software scans the database for potential black spot sites. Figure 14 shows poor accident mapping The result of the black spot search function is shown in figure 15. This method is still in a testing phase in Germany. This seems to be a promising and efficient approach to use stored accident data to develop indicators for safety performance.

Figure 14 : EUSKA displays accidents with injuries in three years in a rural area

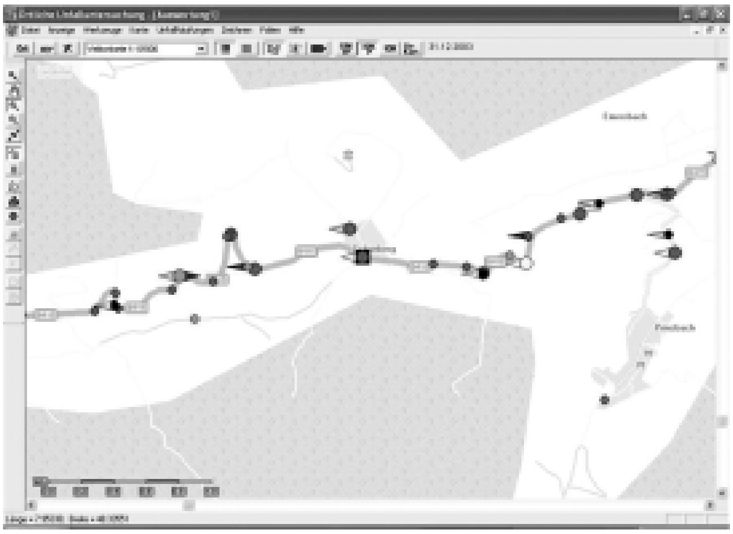
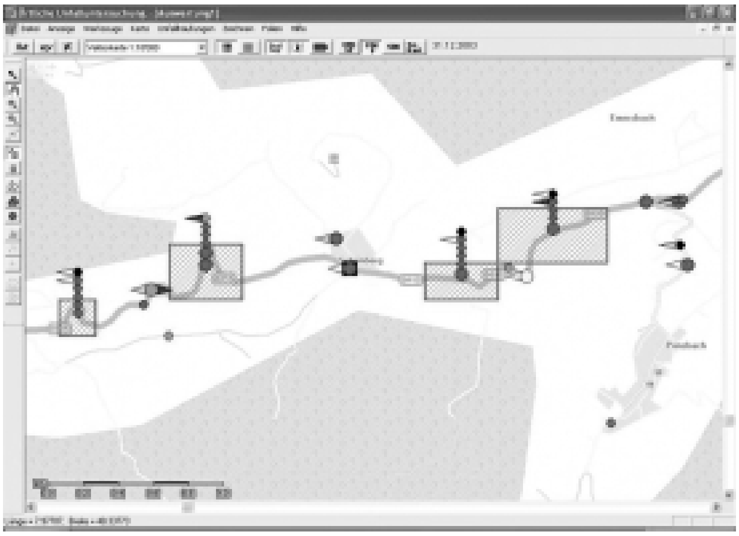
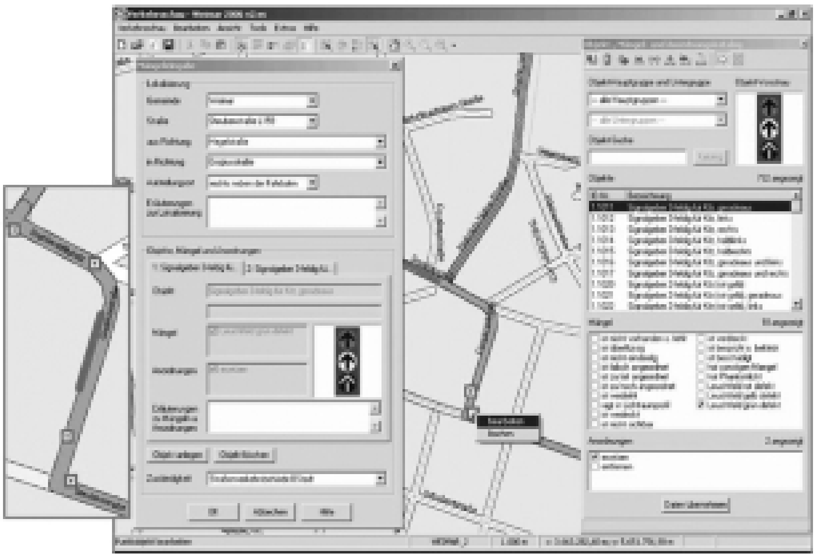


Figure 15 : EUSKA list automatically black spots referring to the parameters of the analyst



It is to be mentioned that also for the road safety inspection exist a software application in Germany, which supports the field inspector to collect the detected defects of the road infrastructure.

Figure 16 : Road inspection base on a software tool developed by Bauhaus University on behalf of the German Insurers Accident Research (UDV)



4. Conclusions

In the beginning of process to plan and to develop new or upgraded road infrastructure there is a need for road safety impact assessment a software solution, which allows on a strategic level comparative analysis of the impact of a new road or a substantial modification to the existing network on the safety performance of the road network. Obviously it is be expected that the tools for this purpose will be part of traffic planning software systems; in Germany specific procedures are used to elaborate cost-benefit relations based on predictive accident costs for planned new roads. Methodical and practical experiences are gathered in Germany with the software system PTV Vision.

Existing road networks and road sections need analytic tools on different levels of aggregation. The development of ESN-procedures in Germany has opened a new area of network analysis on the basis of defined safety potentials.

The developed tool on the micro level-EUSKA has opened in Germany very encouraging possibilities for local in-depth analysis. Additional benefit for police authorities e.g. is the solid accident database generated with EUSKA.

The presented examples serve as a model of what other countries may expect from these solutions for their road infrastructure safety management.

REFERENCES

[1] EWS - Empfehlungen für Wirtschaftlichkeitsuntersuchungen an Straβen - Aktualisierung der RAS-W 86 (FGSV-Nr. 132) 1997

[2] BVWP Bundesverkehrswegeplan 2003
Beschluss der Bundesregierung vom 2.Juli 2003
www.bmvbw.de

[3] ESAS - Empfehlungen für das Sicherheitsaudit von Straβen
Forschungsgesellschaft für Straβen und Verkehrswesen FGSV 2002 [FGSV-Nr. 298]

[4] MAZS - Merkblatt für die Ausbildung und Zertifizierung der Sicherheitsauditoren von Straβen
Forschungsgesellschaft für Straβen und Verkehrswesen FGSV 2009
[FGSV-Nr. 298/1] ISBN 978-3-939715-95-5

[5] ESN (2003)
Empfehlungen für die Sicherheitsanalyse von Straβennetzen, Forschungsgesellschaft für Straβen und Verkehrswesen (FGSV), 2003. ISBN 3-937356-14-2

[6] European Commission DG Energy and Transport High Level Group
Road Safety - Road Infrastructure Safety Management
Report of the Working Group on Infrastructure Safety Status : Public
Version of 19 December 2003

[7] Safety Handbook for Secondary Roads (Ripcord 506184)
WP 13 D 13 Status Final
RIPCORD-ISREST Deliverable D13.doc

[8] TRA Tranport Research Arena Europe 2006
Network Safety Management - A French-German Co-operation
Kerstin Lemke BASt, Germany, Pascal Chambon and Francois Ganneua, Sétra, France
(www.bast.de)

[9] network safety management NSM 2005-06-08
BASt Germany and Sétra France

[10] Black Spot Management and Safety Analysis of Road Networks - Best Practice Guidelines and Implementation Steps
RIPCORD-ISEREST-Deliverable-D6.doc
Michael Sørensen, Rune Elvik (TØ) 2008-02-15

[11] Forschungsgesellschaft für Straβen- und Verkehrswesen (FGSV 2003)
Merkblatt für die Auswertung von Straβenverkehrsunfällen, Teil 1: Führen und Auswerten von Unfalltypen-Steckkarten, FGSV Verlag, Köln, 2003.

[12] Forschungsgesellschaft für Straβen- und Verkehrswesen (FGSV 2001)
Merkblatt für die Auswertung von Straβenverkehrsunfällen, Teil 2: Maβnahmen gegen Unfallhäufungen", FGSV Verlag, Köln, 2001.

[13] Report ot the working group on infrastructure safety
European Commission DG Energy and Transport
High Level Group Road Safety
Report of the Working Group on Infrastructure Safety
Status : Public - Version of 19 December 2003

[14] ISM 2008 Weimar Germany,
PTV AG and UDV : Committed to improving traffic safety (Andre Münch, Heiko Voβ)

[15] DIRECTIVE 2008/96/EC
OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 19 November 2008 on road infrastructure safety management