B. Pund
TUEV Nord Institute for Traffic Psychology, Hannover, Germany

D. Otte, M. Jänsch
Accident Research Unit Medical School Hannover, Germany

Systematic of Analysis of Human Accident Causation – Seven Steps Methodology

Abbreviated System for the Assessment of Accident Causation in In-Depth Accident Studies

Abstract

The “Seven Steps Method” is an analysis and classification system, which describes the human participation factors and their causes in the temporal sequence (from the perceptibility to concrete action errors) taking into consideration the logical sequence of individual basic functions. By means of the “seven steps” it is possible to describe the relevant human causes of accidents from persons involved in the accident in an economic way with a sufficient degree of exactitude, because the causes can be further differentiated in their value (e.g. diversion as external diversion with regard to impact due to surroundings) and their sub values (e.g. external diversion with regard to impact due to surroundings in the shape of a “capture” of the perception by a prominent object of the traffic environment). Theoretically it is possible that one or more causing moments can be assigned to a person involved in an accident in each of the “seven steps"; however it is also possible to sufficiently clarify the cause in only one level (examples for this are described).

In the practice of accident investigation at the site of the accident, the sequence chart is also relevant. With its assistance the questioning of the people involved in an accident can be accomplished in a structured way by assigning a set of questions to each step.

Introduction and Objective

Due to the constant decrease of the casualties and fatalities arising from traffic accidents, questions regarding the possible accident avoidance potential come into the foreground. Also the implementations of many technical sensors and systems into the new vehicles for the simplification of actions and navigation assistance when guiding a motor vehicle through increasingly dense traffic can cause misinterpretations and spurious actions of the drivers. This has to be recognized for a future optimization of measures and has to be acted on. Requirements of a scientifically oriented accident research increase and have to be focused on the causes of accidents. The interests of the team active at the site of the accident immediately after such an event has taken place have to be taken into consideration. On the one hand the road user is still in place, and on the other hand cannot always be pursued at a later stage due to costs. For this reason, a special procedure using special questions was developed in the course of the on-scene accident investigation in Hannover (GIDAS German in-Depth Accident Study). This procedure makes it possible also for a non-psychologist to compile a substantial amount of information from the persons involved, in order to be able to better determine the cause of the accidents and to facilitate the coding for data storage at a later stage. An initial approach was introduced during ESAR 2004 [1]. Based on this foundation further developments of purposeful questioning were conducted locally. The results of which are presented now on the occasion of the ESAR 2006.

A systematic scheme for the analysis of the humanly accident causes by investigations at the site of the accident should include the following four characteristics:

- The structure is to be oriented at the temporal sequence of the human functions and processes in the seconds before the accident: initial conditions (e.g. functional restrictions of the perception ability), perception (attention, registration of the situation), judgment (risk assessment, avoidance planning) and acting (action design, execution, driving manoeuver).
- Each analysis step shall be clearly definable and clearly feasible by test criteria of which the causes are ascribable to associated human processes and basic human functions.

- The structure of the analysis model shall exhibit an accordance as high as possible with the structure of the questionnaire for application at the site of the accident or with the subsequent questioning, in order to ensure an internal logic for a time-economic and “intuitive” questioning.
- This way together with other cause factors from the domain ‘vehicle technology or road infrastructure’ the answers and results of the analysis can be uniquely assigned to an analysis step of the flow chart and in coded form, serve to describe a certain type of cause.

The set-up of the procedure and analysis model of “7 steps” took place due to earlier theoretical considerations [1] and via adjustment of psychological models for the causes of accident to the requirements of “in-Depth"/"on-Site” analyses on accidents with the emphasis on the recording and description of the humanly caused influences and their interaction with the conditions of the vehicle and the driving environment [2-4].

Practical experiences by questioning people involved in accidents influenced the structure of the model, in particular in view of the handling of the model in the shape of a semi-standardized questionnaire.

The structure of the Sequence and Analysis Model

In order to avoid reductionistic statements about causes of accidents, the common causes (e.g. “inattentiveness") were defined as determinators (decision criteria) on the basis of which human cause factors described in traffic-psychological literature are identifiable (e.g. kind of the diversion, which leads to the restriction of the attention).

The required model explicitly covers the identification of the type of error or mistake of the person involved in the accident in the pre-crash phase besides an as exact description of the human cause factors as possible by feature categories in each analysis step. To that extent the

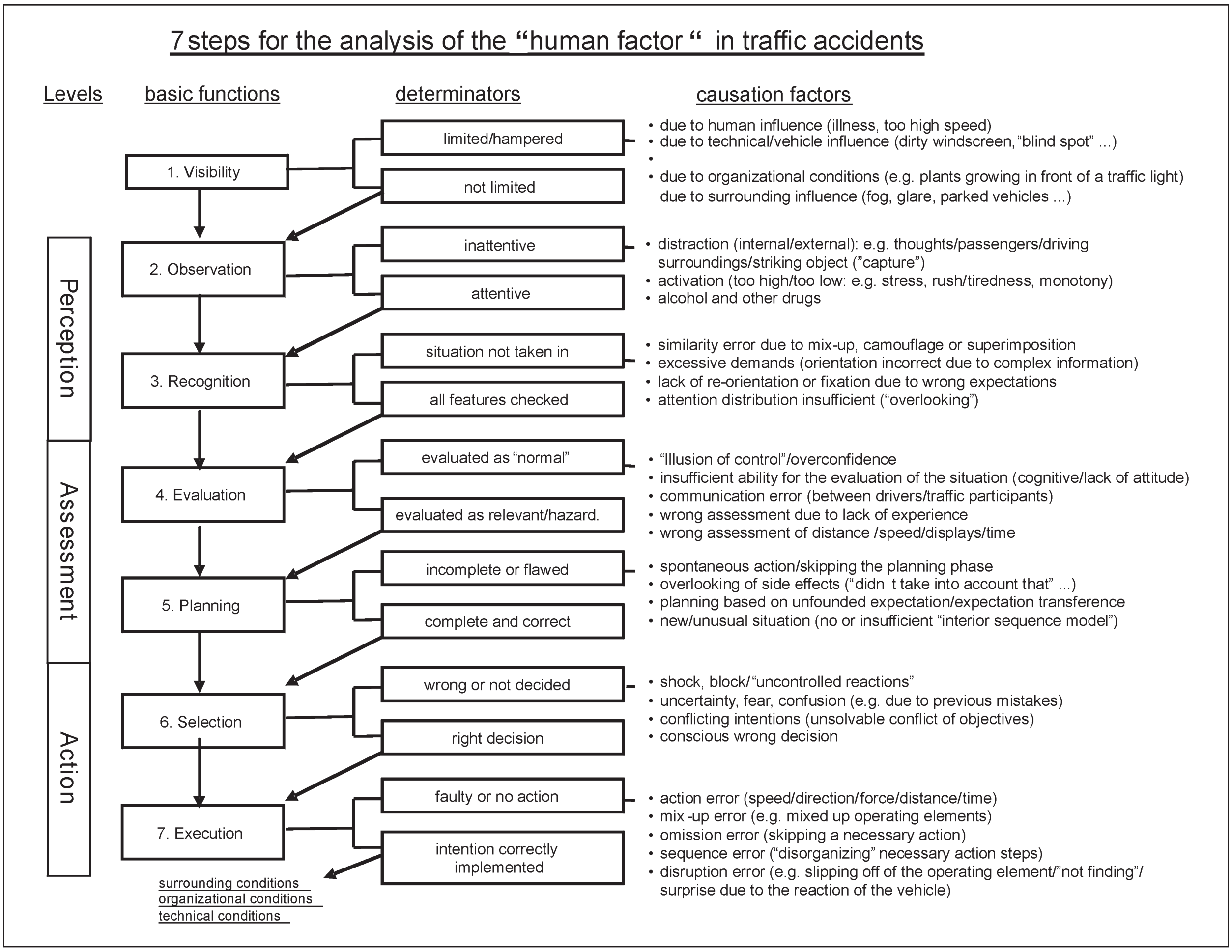

Figure 1: Method structure of the analysis model

model of the “7 steps” also has a theoretical proximity to well-known findings of the error analysis (e.g. [5, 6]).

Following the awareness of the multiple determination of accidents, the model can be used to identify accidents causes and/or errors in several steps on the one hand; in other accidents the analysis can end at only one certain step, because the cause may be assignable with a sufficient degree of certainty. A schematic representation of the method structure is represented in Figure 1.

In order to prevent a too fast interpretation as well as “obviousness” and to prevent overlooking ‘hidden’ causes, however, a questioning as complete as possible and an analysis based on all 7 steps is appropriate. If the interviewer adheres to the questioning pattern derived from the model, the specific answer of the person involved in an accident can be assigned to a step of the model at a later assignment. Possible false assessments can be avoided by the fact that the basic function involved is analyzed. The statement “I thought that nothing would happen” for instance can be assigned either to Step 4 (confidence error) or to Step 5 (overlooking side effects).

An exact assignment can be gleaned, if the question is asked whether this error arose when estimating the risk of the situation or if the risk was recognized, in the next step of the planning of the avoidance reaction. In our example the person asked answered that he had not noticed that another vehicle was driving next to his own car during the instigation of his evasion manoeuver. This elaboration shows that this cause has to be coded as Step 5 as well, because he neglected “side effects” in his action design.

The coping with a traffic situation/a traffic conflict/a hazard constellation presupposes an unhindered information access on side of the road user. The “7 steps” therefore start with a simple analysis of the perception conditions at the site of the accident and the perception potential of the person involved in the accident, as represented in Figure 1.

Accident Causation Analysis with Seven Steps ACASS

First Step: Did the road user objectively have access to the relevant information (or could he have had)? What prevented him from access to the information?

The evaluation of perception-restrictive conditions can refer on the one hand to clearly recognizable characteristics (e.g. vegetation in front of a traffic light). On the other hand, the entire perception condition can play a role in the analysis of the causes of accidents (e.g. dense fog, sun glare). In the latter case it is assumed that the access to information for the road user was at least difficult (e.g. despite darkness), however cause factors of the following analysis steps will also play a role. Furthermore, restrictions of the assimilation of traffic-relevant information can be caused by influences due to the vehicle (e.g. structural units or additional load) or organizational conditions of traffic (blocked view). After all, the functions of the human sensors and the efficiency of the peripheral nervous data processing system determine the availability of traffic-relevant information. Here long-term health problems limiting perception (e.g. central and peripheral amblyopia) are of importance.

The influence of the selected speed also falls under the first analysis step, as at an increased speed situation details and situation changes are less well perceptible, even with increased attention.

The cause factors connected with reduced attention are collected in the second step, where in contrast to the first step with the acquisition of long-term influences of human perception, here currently effective cause factors are important: diversion, activation and alcohol/drugs.

The further analysis at the site of the accident deals with the question, of whether the person involved in the accident, after the perception possibilities were given in all likelihood, has also attentively observed critical or relevant elements of the situation before the accident or whether he could at all, e.g. was he prevented due to the influence of alcohol. Furthermore, the reasons for a lack of “observation accuracy” can consist of a diversion, which can be caused both internally (e.g. diverting thoughts) and externally (e.g. discussion with passengers, diverting attractions in traffic). Attention can be tied also by the fact that the driver and/or road user is either too strongly activated (nervousness, stress, hurry) or the activation is too low (tiredness, circadian rhythm, driving under monotonous conditions). A special case of an extreme diversion is called “capture": the entire attention is focused on a “pre-dominant” event or object.

The answer frequently given by people involved in an accident to have “overlooked” something in traffic is assigned to the third step: the situation was not completely grasped, e.g. because of an insufficient distribution of the attention or a missing re-orientation towards the possible source of danger due to unfounded expectation of the situation development.

In this step it is assumed that despite attentive observation it is not automatically ensured that the road user also recognizes what the situation or a situation detail means regarding to the solution of a traffic conflict. The identification can also be limited by the fact that relevant situation characteristics cannot be differentiated ("fusion", “camouflage") or that a mistake is made due to the similarity to other objects. Furthermore, the identification can be prevented by excessive demands. The driver does not orientate sufficiently, because he is overtaxed either by the situation as such or by individual details (complex information transfer). The complexity of the information transfer is classified on the basis of a classification scheme by the analysis of the perception conditions at the site of the accident.

However, if the relevant characteristics of the accident situation were recognized, in the fourth step the question is to be raised by the interrogator, whether the road user judged the situation properly.

The most frequent false assessments here refer to the fact that the road user judged certain elements of the traffic situation as not relevant or not risky, even though no “normal situation” is present, but a need for orientation within a critically changed situation. False assessments can refer here to distances, speeds, space situation or indicated information, furthermore faulty assessments due to a lack of experience or inadequate transfer of experiences from similar situations can occur. In this step of the analysis, the “illusion of control” also comes into effect: the driver accepts a high risk, since he thinks that he can deal with the traffic situation without problems. The driver simply has excessive faith into his own abilities or into the trouble-free development of the traffic situations. Further causes and/or assessment errors lie in the inability of the involved person to properly judge the situation or in communication errors between road users.

The fifth step of the causation analysis refers to the usually very short phase of the planning of behavior options, if the situation were assessed as risky or relevant.

If the interrogator should have indicators for the fact that the person involved in accident was surprised “out of the blue” by the sequence, it must be assumed that the time was not sufficient for the planning of behavior (e.g. “I could not think straight"). Furthermore, it may be that sufficient time was given for the execution of an action design, the traffic participant however had wrong expectations ("that’s the way it always was") or ignored secondary effects (e.g. “I had not expected him to start off..."). A further “mistake in reasoning” can be present in those cases, where the road user had a wrong “mental” model of the sequence of situation, e.g. because the situation is unknown or unusual to him.

The sixth step of the causation analysis covers the decision which the driver drew from the previous planning step.

Here it may be possible that the road user either did not decide on anything or decided wrongly against his previous conclusion. The causes may on the one hand be derived from shock symptoms (shock, block, “uncontrolled reactions"), which prevent purposeful actions, on the other hand fear and confusion may prevail, e.g. due to a chain of preceding errors. A wrong decision for or against an action can also be that the road user was unable to decide between two equivalent goals, thus was caught between unsolvable conflicting aims.

However, if the road user decided correctly, the errors can be due to the concrete actions taken and/or their execution in the seventh step.

If the road user did not act properly or not at all, an execution error is usually present, whereby the interviewed person acted erroneously concerning speed, strength, direction or distance. Further errors in the execution refer to mix-ups, omissions, wrong sequence in actions as well as to interrupted actions (e.g. surprise due to the intervention of the vehicle assistant or the “non--finding” of a control element). The concrete avoidance reaction is also systematically recorded, according to kind of driving maneuvers and their qualitative value (e.g. abrupt braking in combination with swerving to the right).

The analysis of the “human factor” in traffic accidents ends with this seventh step, where the analysis is continued, should the road user have acted “correctly” according to the analysis. (Expansion of Seven Steps).

Here in principle two possibilities are conceivable for the further analysis steps, which can also be present simultaneously: the organizational, environmental or technical conditions are faulty and/or the causing part is with the collision partner.

The method of the “7 steps ” has the advantage of recording the internal processes of human behavior to such an extent that during the inquiry at the site of the accident a clear and appropriate cause can be established very quickly. This possibly cannot be recognized in as much detail as by means of an isolated deep-psychological questioning. For the work at the site of the accident is it extremely important to be able to change the questioning process dynamically or to terminate it completely. The interrogator can terminate the questioning, if he found a clear allocation of a cause of accident to one level of the “7 steps”. Nevertheless a further analysis can take place at a later time, in order to find further causes of the accident; to that extent the alternatives at the point of decision, whether in the respective step a significant cause is present or not, are to be seen rather as a working hypothesis. Thus in addition to the decision, whether the driver was inattentive or attentive (2nd step) from his reports “inattentiveness by diversion”, a further cause could be present (additionally e.g. a communication error, see step 4) in the following phases.

Case Study: Example of the Application of the Seven Steps Method for the Purpose of Analyzing and Classification of the Causes

Case 05-928, in the village Heessel, rural Lower Saxony in the district Hannover, on November 22nd, 2005, around 5.40 p.m.: a passenger car of the type Mercedes turns left from a local road on the privileged through road 188 (village street) and collides with a motor cycle of the make Yamaha coming from the left. See Figure 2 for a sketch of the accident site.

At the time of the accident it was already dark. The pictures 1 and 2 show the view of the car driver approaching the junction, once at night with artificial lighting and once during daytime. In picture 3 you can see the perspective of the car driver when looking to the left. The picture was taken from behind the bus stop. In the background you can see the lights of a petrol station. Picture 4 shows the view to the left of the car driver directly at the junction, however, taken at daytime. The view of the approaching motorcycle rider can be seen in picture 5. The damages of the car (picture 6) show that the car ran into the side of the motorcycle which was coming from the left.

The results of the retrospective questioning resulted in the following classifications into the “7 steps":

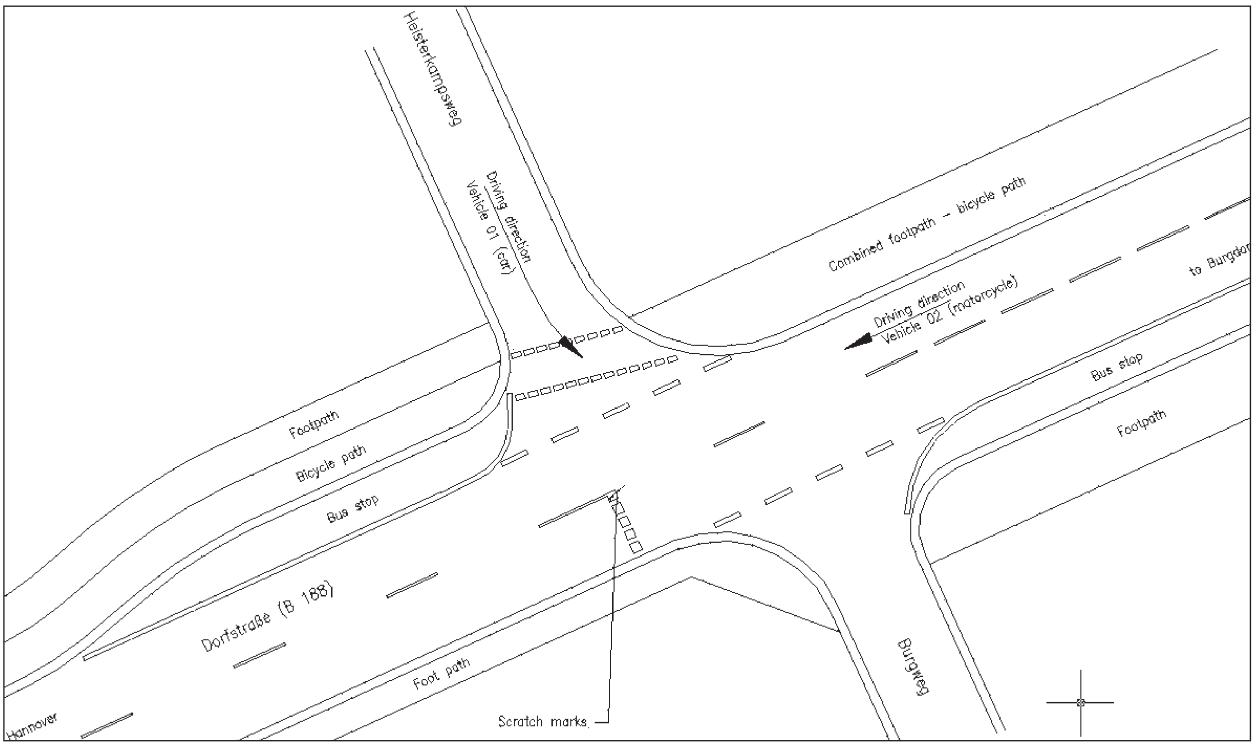

Figure 2: Sketch of the accident site

In the first step the driver was asked about the perception conditions. “Everything was just as always, only somewhat dark and murky… no rain, but the roads were somewhat moistened, no one was in front of me and none behind me... the only exceptional thing was that the road was free for me on both sides, the 188 is usually always busy.” Also, as no illness-related or visual problems were present, in the second step the degree of attentiveness was of interest: “I had started at home and was on my way to play tennis; it was just like always... I had twenty minutes to cover a distance of 5 kilometers, thus I was rested, relaxed, everything was fine... approached the 188, coming from the Heisterkampsweg, I looked to the right, no vehicles approaching from any direction, no headlight to be seen, I looked to the left, saw nothing, started slowly across the intersection.” As questions concerning diverting conditions were also answered in the negative, in the third step it was asked whether the situation was completely taken

Picture 1: View of the car driver approaching the crossing

Picture 2: Same view as in Picture 1, during daytime

Picture 3: Car driver’s view to the left. (picture taken from behind the crossing)

Picture 4: Car driver’s view to the left at the crossing

Picture 5: View of the motorcycle rider approaching the crossing during daytime

Picture 6: Damages on the car

in briefly before the accident: “I do not know. I have sorted everything in my head and am of the opinion that I did not identify the headlight of the motorcycle as a headlight. Simply because it was a light that belonged there anyway. Because there in the back in this corner there is a gas station, it is also very brightly lit and the light was assimilated. It must have approached me directly from ahead, thus it did not seem to move and therefore I imagined it to be a lamp. When it swerved, I noticed the fact that the thing itself moved of its own and then everything was already history.” Here a cause factor due to incorrect identification was assumed: Coding 3.1 (third step “recognition"; similarity error due to mix-up, camouflage or superimposition). In the course of further questioning it was found that the driver made no assessment or interpretation error in the fourth step, as he interpreted the risk as such correctly, however too late: “In one instant I saw a lamp, which moved and then I identified it as a motorcycle, I stopped, but the motor cyclist was no longer able to take evasive action, to avoid hitting me. He slightly touched the front of my car at the bumper and there received the jolt”. A possible error in the planning of the avoidance reaction (fifth step) could be excluded. His planning concerning the possible emergency reaction was correct. In the sixth step no decision problem could be found, as the decision to break at the moment the danger was recognized was correct. Decision errors due to shock phenomena or due to conscious wrong decisions did not arise. A seventh step does not apply here any longer, as no execution errors are recognizable, when he recognized the danger he stopped his vehicle immediately. The concrete driving maneuver “braking” is determined in the coding pattern for the description of the avoidance reactions and possible combinations of the same.

Conclusion and Outlook

Derived from practical experiences when questioning at the site of an accident a hierarchical system was developed for the recording and evaluation of human influences causing traffic accidents with the background of psychological error analysis. The methodical procedure follows a system, which images the relevant perception, evaluation and action processes from the view of each person directly involved in the accident on the basis of an analysis of the perception conditions. The perceptive, cognitive and motor processes effective on these three levels are determined more closely in each case in two subcategories (basic functions), so that sequence systematics including the base function ("perception possibilities") covers seven steps altogether. The “7 step method” is an analysis and order system, which describes the human participation factors and their causes from the temporal sequence (from the perceptibility to concrete action errors) with consideration of the logical sequence of individual basic functions. The model is influenced by the idea of interactive accident models as an analysis method of the human information process (cognitions, actions and errors interacting with the environment; e.g. [7]). Furthermore it refers to dynamic sequence models (e.g. [7-9]) and emphasizes the functioning of human processes on their regulation levels and the subsequent errors (e.g. [5]). With assistance of the “seven steps” it is possible to further describe the relevant human causes of accidents of persons involved in the accident with a sufficient degree of exactitude in an economic way, because the causes can be further differentiated in their value (e.g. diversion as external diversion with regard to surroundings) and their subvalues (e.g. external diversion with regard to surroundings in the shape of a “capture” of the perception by a prominent object of the traffic surroundings). The “seven-step-method”, also called ACASS Accident Causation Analysis with Seven Steps, represents a practical analysis system, which is easy and simple to apply by scientific recording teams in the course of in-depth investigations and allows an allocation to possible causes of accidents in a fast analysis in form of a screening procedure. It must surely be regarded as a simplified kind of analysis according to psychological criteria, as in this way no background of deep-seated human behavior error is recognizable. ACASS, however, explicitly covers the identification of the kind of the error or mistake in the pre-crash phase by the person involved in an accident, besides an as exact as possible description of the human cause factors by feature categories in every analysis step.

ACASS offers a logical questioning pattern that can be used to determine the possible cause factors in their temporal sequence. This also facilitates the mental reconstruction of his course of action for the interviewed person concerning the setting-off of the accident and its avoidance. The practical application of ACASS also supplies room for future advancements of the system in the following points:

- the extension of possible cause factors of the individual steps of the human factor and the codability of these factors, e.g. for the recording of the causes within a data base system,
- the recording and coding bar of extended possible causes of accidents from the areas organizational, environmental, action-specific and technical causes, in particular in view of the modules of telematics, which will be found in vehicles in the near future.

ACASS is also suitable to be integrated into these extensions.

References

1 B. PUND, D. OTTE: Assessment of Accident Causation from the Viewpoint on In-Depth Investigation on Scene – Traffic Psychological Methodology on Examples of In-Depth Cases by GIDAS. In: Reports on the ESAR-Conference on 3rd/4th September 2004 at Hannover Medical School, Berichte der Bundesanstalt für Straßenwesen, Heft F 55, 2005.

2 D. OTTE: The Accident Research Unit Hannover as Example for Importance and Benefit of Existing In-Depth Investigations, SAE 940712, 1994

3 B. PUND, W.-R. NICKEL: Psychologische Untersuchungen am Unfallort. Berichte der Bundesanstalt für Straßenwesen, Heft M 27, 1994

4 B. PUND, D. OTTE: Zusammenführung von technischen, medizinischen und psychologischen Erkenntnissen bei der Unfallerhebung vor Ort. In: F. MEYER-GRAMCKO (Hrsg.), Verkehrspsychologie auf neuen Wegen: Herausforderungen von Straße, Wasser, Luft und Schiene. Bonn: Deutscher Psychologen-Verlag, 1999

5 J. RASMUSSEN: The Concept of Human Error and the Design of Reliable Human-Machine-Systems. In: H.P. WILLUMEIT & H. KOLREP (Hrsg.), Verlässlichkeit von Mensch-Maschine-Systemen, S. 255-271, Berlin: Technische Universität Berlin, 1995

6 J. REASON: Menschliches Versagen: Psychologische Risikofaktoren und moderne Technologien. Aus dem Amerikanischen übersetzt von J. GRABOWSKI. Heidelberg: Spektrum Akademischer Verlag, 1994

7 Chr. HEINRICH, K.M. PORSCHEN: Die Bedeutung interaktiver Unfallmodelle für die Straßenverkehrssicherheitsforschung, Zeitschrift für Verkehrssicherheit 35, 1989

8 G.L. McDONALD: The Involvement of Tractor Design in Accidents, Research report 3/72, Department of Mechanical Engineering, University of Queensland, 1972

9 H.J. KÜTING: Zur Analyse von Denk- und Handlungsfehlern beim Autofahren, W.-R. NICKEL (Hrsg.), Fahrverhalten und Verkehrsumwelt, Köln, Verlag TÜV Rheinland, 1990

10 J. SURRY: Industrial Accident Research: A Human Engineering Appraisal, University of Toronto, Department of Industrial Engineering, 1969