STANDARDIZED PRE-CRASH-SCENARIOS IN DIGITAL FORMAT ON THE BASIS OF THE VUFO SIMULATION

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Abstract - The sequence of accident events can be classified by three essential phases, the pre-crash-sequence, the crash-sequence and the post-crash-sequence. The level of reliability of the information in the GIDAS-database (German In Depth Accident Study) is provided predominantly on the passive side. The period to evaluate active safety systems begins already in the pre-crash-sequence. The assessment of the potential of sensor- or communication-based active safety systems can only be accomplished by a detailed analysis of the pre-crash-phase. Hence the necessity to analyze the early period of the accident event in detail arises.
This is possible with the help of the digital sketches of the accident site and the simulation of the accident by a simulation method of the VUFO GmbH.
After simulating the pre-crash scenario it is possible to generate additional and standardized data to describe the pre-crash-sequences of an accident in a very high detail. These data are documented in a second database called the GIDAS Pre-Crash-Matrix (PCM).
The PCM contains various tables with all relevant data to reproduce the pre-crash-sequence of traffic accidents from the GIDAS database until 5 seconds before the first collision. This includes parameters to describe the environment data, participant data and motion or dynamic data.
This paper explains the creation of the PCM, the simulation itself and the contents and structure of the PCM.
With this information of the pre-crash-sequence for various accident scenarios an improved benefit estimation and development of active safety systems can be made possible.

INTRODUCTION

Active safety systems take over a leading role in the prevention of traffic accidents and the decreasing of the injury severity more and more. To estimate the benefit of these active safety systems or system combinations the simulation of real traffic accidents is essential and can only be accomplished by a detailed analysis of the pre-crash-phase.

The information registered in the GIDAS database cover predominantly the passive aspects of an accident, thus the crash- and post-crash-phase (as shown in

Figure 1).

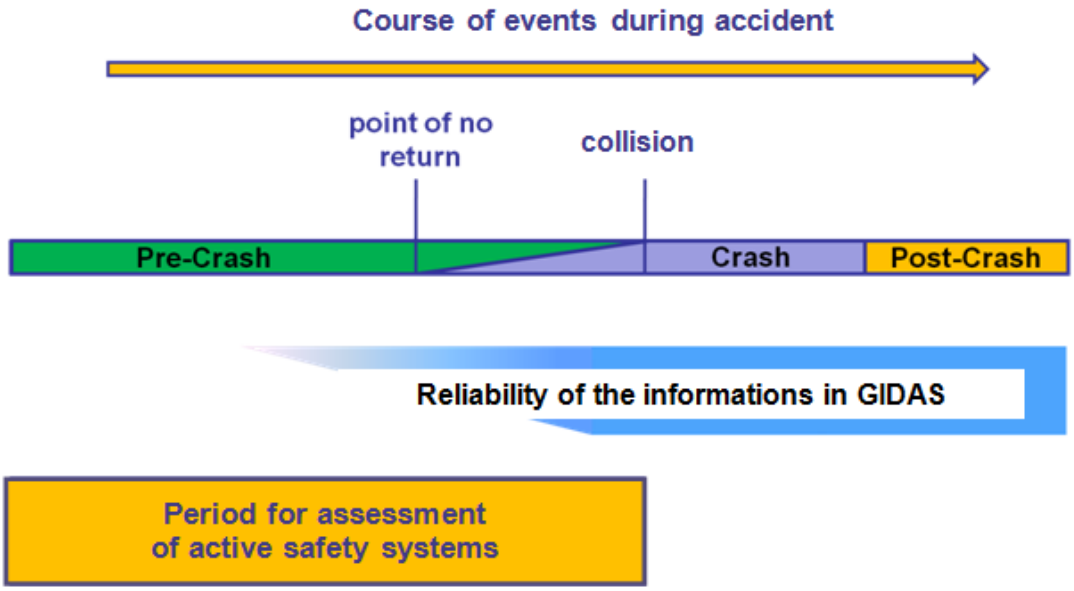

Figure 1: Accident event

The crucial period to assess active safety systems begins already in the pre-crash-phase.

The analysis of this early period of an accident is feasible by the use of the digital sketches of the accident and by the simulation of the accident until the collision based on these sketches. Therefore a simulation model has been developed by the VUFO GmbH.

GENERAL PROCEDURE – REALIZATION

To simulate the pre-crash-phase until the first collision, vehicle data and reconstruction data from GIDAS are used to determine specific parameters of the two colliding participants. The digital sketch shows the trajectories of the participants. By the help of this information the pre-crash-phase can be simulated with the VUFO simulation model. The VUFO simulation model has been built in Simulink. The Simulink model uses additional vehicle dynamic software to reproduce the vehicle behaviour during the simulation of the pre-crash-phase. The information from the digital sketch and the results of the simulation of the pre-crash-scenario are concentrated in PCM.

Input data from GIDAS

For the simulation of the pre-crash-phase accident data from GIDAS has been used. Relevant input data for the simulation are vehicle parameters as width, length, weight and braking mode. Further important input data arises from the reconstruction such as starting and collision velocities, as well as brake applications of the participants and road conditions. These data are coded in the GIDAS database for all participants of an accident. In the pre-process of the simulation the input data is extracted from GIDAS and converted to a usable format.
GIDAS is the largest in-depth accident study in Germany. The data collected within the GIDAS project is very extensive and serves as a basis of knowledge for different groups of interest.
Due to a well defined sampling plan, representativeness with respect to the federal statistics is also guaranteed. Since mid 1999, the GIDAS project has collected on-scene accident data in the areas of Hannover and Dresden. GIDAS collects data from accidents of all kinds with at least one injured person. Due to the on-scene investigation and the complete reconstruction of each accident, it gives a comprehensive view on the individual accident sequences and its causation.
The project is funded by the Federal Highway Research Institute (BASt) and the German Research Association for Automotive Technology (FAT), a department of the VDA (German Association of the Automotive Industry).

Digitalization of accident sketches

During the documentation of an accident a case file is generated parallel to the GIDAS database. Its contents are photographs of the accident, an overview of the injuries and of the pattern of damage and an accident sketch.
In order to use the sketch as input for the simulation a concept has been developed to digitize existing accident sketches.
Therefore the existing graphical accident sketch is enhanced manually with various layers for relevant boundaries of the road, different road markings, sight obstructions and the driving courses of the participants. Subsequently the graphical accident sketch is digitized.
This process is described in Figure 2.

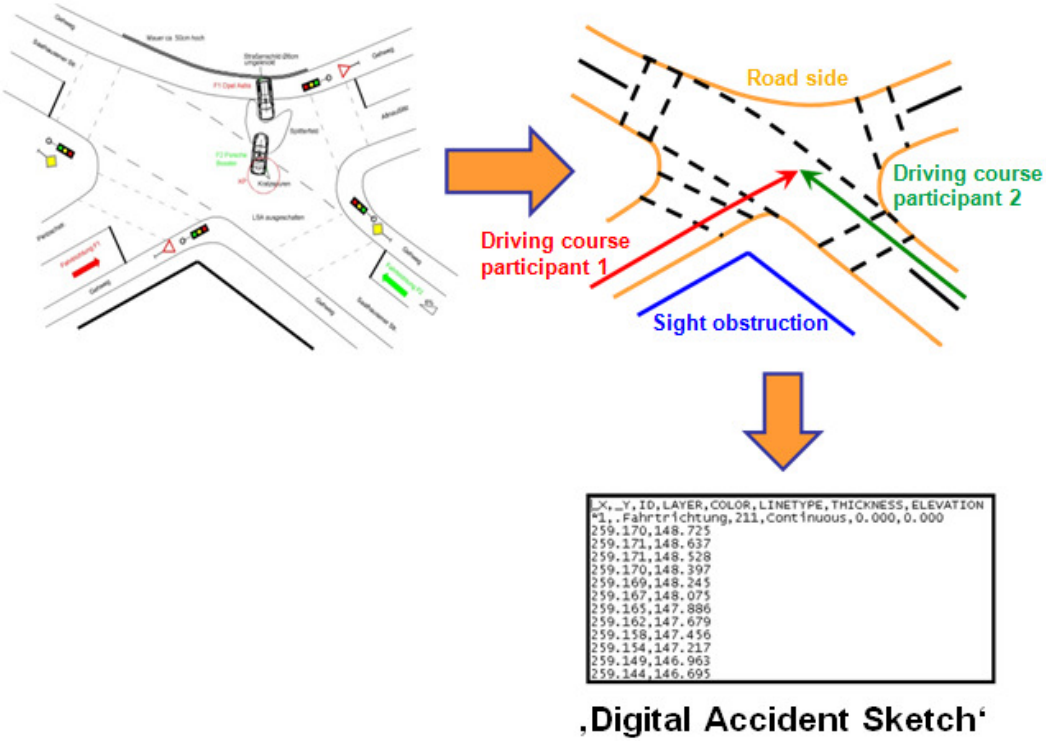

Figure 2: Creation of 'Digital Accident Sketch'

Via this digital accident sketch it is possible to determine the positions of two participants of the accident for various TTC's (time to collision) considering the driving velocities.
The determination of these positions is carried out by forward simulation of the real accident. InFigure 3 such a determination of the positions of the participating vehicles is shown.

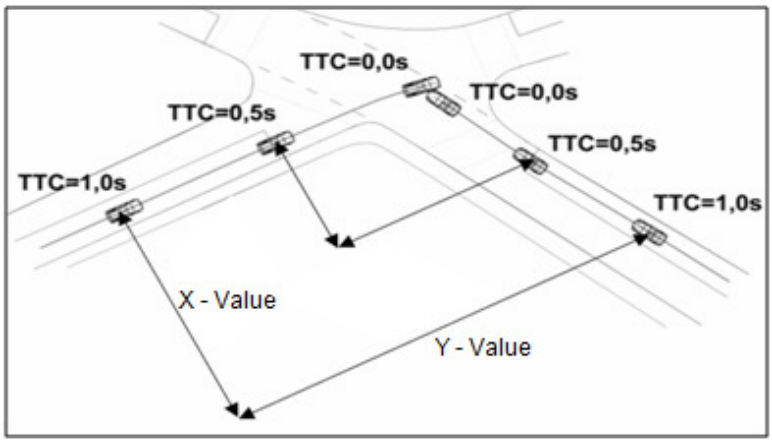

Figure 3: Determination of the vehicle position depending on the TTC

STRUCTURE OF THE GIDAS-PRE-CRASH-MATRIX

The PCM contains various tables with all relevant data to reproduce the pre-crash-phase of traffic accidents from the GIDAS database until 5 seconds before collision. As mentioned before the PCM results from the simulation of traffic accidents coded in GIDAS by a simulation model of the VUFO. If the time period of the reconstruction is less than 5 seconds the course of the vehicle is computed by linear backward calculation to be able to simulate the whole 5 seconds. Thus the reliability of the PCM dynamic values is only given for the time period of the reconstruction.
Figure 4 shows the hierarchy of the tables and their usage.
So far for all accidents registered in the PCM at least one participant is a passenger car, the other participant can be another passenger car, a pedestrian, a bicycle or a motorcycle.

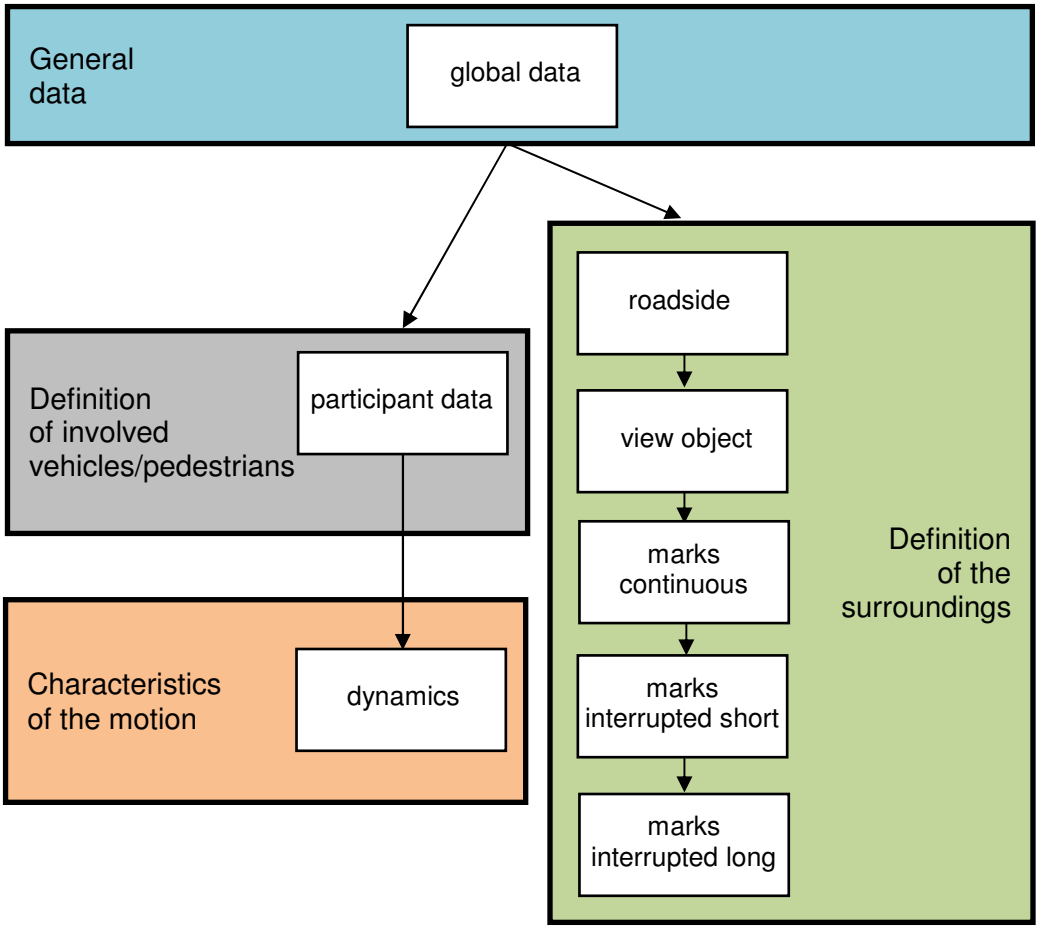

Figure 4: Structure of the PCM

Global data includes general information about the accident such as the number of involved participants. So far for accidents with more than two participants only the two participants of the first collision are regarded in the PCM.
The participant data contains all relevant variables to parameterize the vehicles. This data will be used to model the geometry and further attributes of the participant during the pre-crash-phase. For pedestrians, bicycles and motorcycles default values concerning the geometry are set. The data for passenger cars are derived from GIDAS. An important variable is the friction coefficient, which is determined from the conditions of the road surface.
The table „dynamics“ gives the position, the velocity, the acceleration and the yaw angle of the vehicle at each time step of the simulation. Furthermore the steering angles of the left and right front wheel are specified for each time step. Another variable provides the information whether the brake is actuated by the driver at the given time step or not.

The definitions of the surroundings are obtained from the digital sketch. The road side and road markings divided into short and long interrupted marks and continuous marks as stop lines are of special interest. Sight obstructions are registered in the table ‘view object’.

FIELDS OF APPLICATION

The PCM offers a wide range of possibilities to study the pre-crash-phase in detail and to assess active safety systems for a large number of accidents. Additionally a reproduction of the simulation of the accident is given and a comparable simulation on the basis of GIDAS is guaranteed for different applicants.

Assessment of active safety systems

Fehler! Verweisquelle konnte nicht gefunden werden. shows the actual possibilities of such a pre-crash simulation.
On the left side the original accident and on the right side the modified accident within an active safety system is shown. Equipped with the active safety system the vehicle comes to halt earlier and the accident can be prevented. It is visible when the opponent vehicle comes in sensor range and the analysis of the simulation results gives for example warning and braking times of the sensor system. Simulations of real world accident scenarios as basis for safety system application can be easily build up from the PCM. The next pictures show an example accident with and without an active safety system.

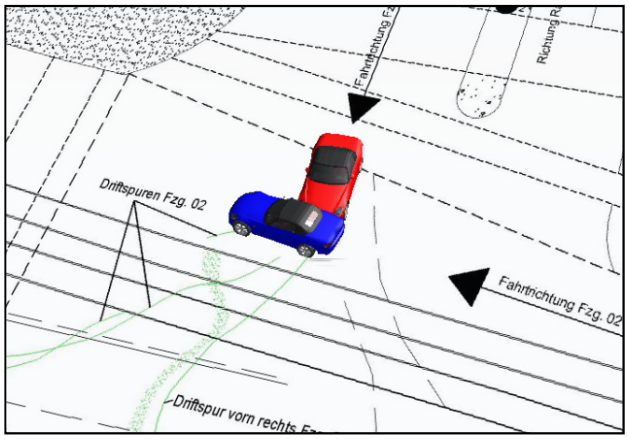

Figure 5: Collision Position of real accident

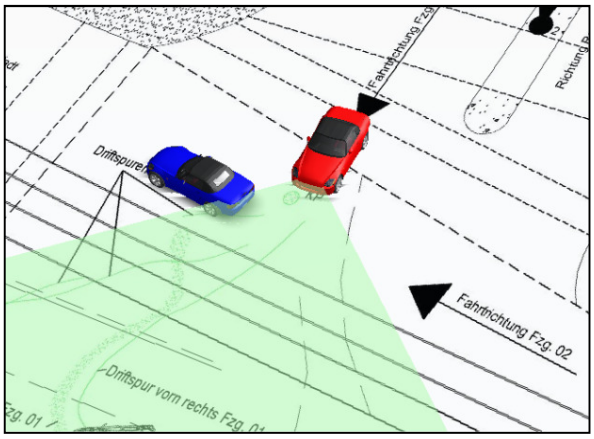

Figure 6: Position of the virtual accident (with active safety system)

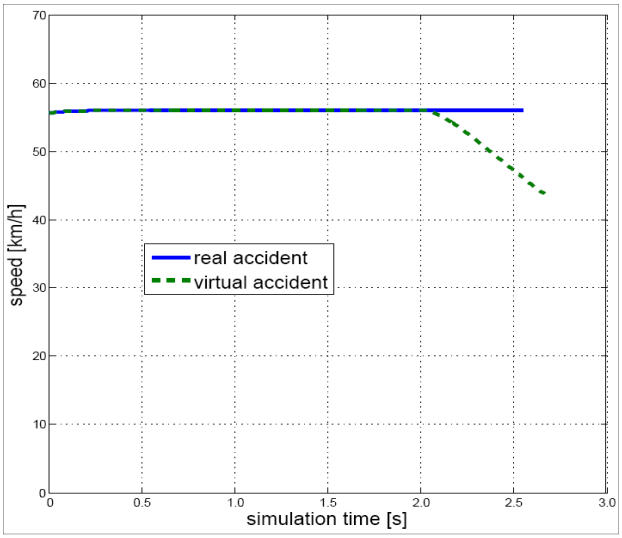

Figure 7: Comparison of the speeds from real and

The speeds up to the crash of the real and virtual accident scenario are shown in Figure 7. In this way the PCM deliver the speed base line (blue, not dashed) and of course the trajectories of the participants. This speed base line can be compared to a speed line of a virtual accident scenario e.g. in Figure 6 and the result can be carried out for actual more than 4000 accident scenarios in the current PCM. The number of accidents in the PCM grows gradually.

virtual accident scenario

Pre-crash-scatter-plots

The time flow of the position of the collision opponent can be illustrated from the point of view of the vehicle equipped with the sensor system via pre-crash-scatter-plots [1].
For this purpose the center of gravity of the vehicle with sensor system is translated into zero-point position and the front end of the vehicle is aligned with positive y-direction. The center of gravity of the collision opponent is translated analog with the same transformation factors and then can be looked at from the point of view of the vehicle with sensor system. An example is shown in Figure 8.

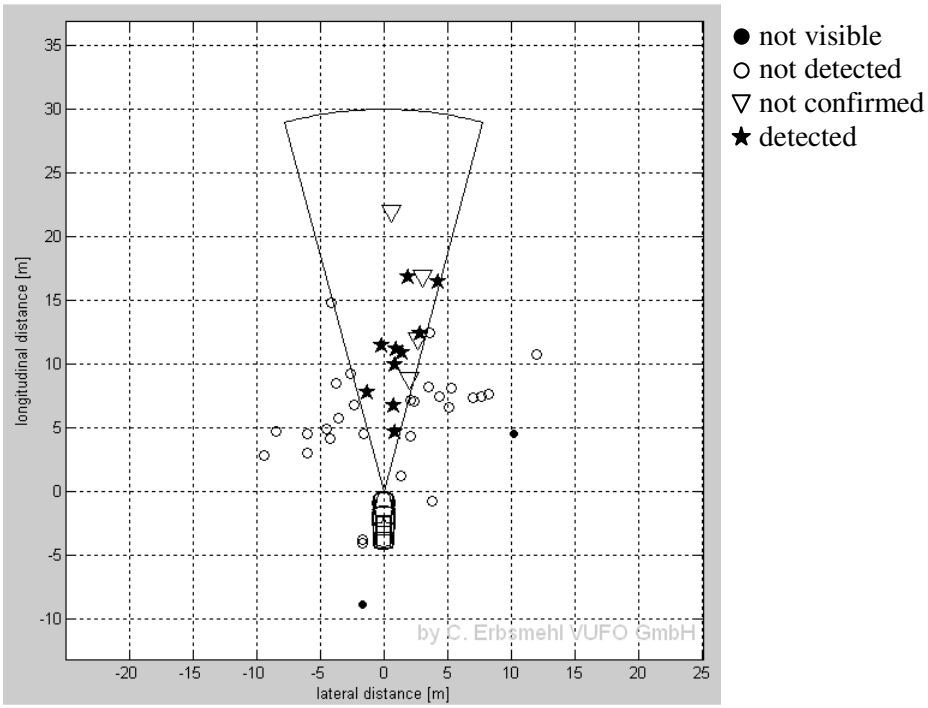

Figure 8: pre-crash-scatter-plot, 44 bicycles, TTC=1s, Detection

The results can be used to design reasonable sensor geometries or to estimate the efficiency of implemented active safety systems in combination with sensor characteristics. Furthermore the view conditions and the times of visibility can be analysed.
These are two examples for the usage of the GIDAS PCM. There will be more possibilities and methods for using the PCM in the future.

CONCLUSION

The PCM gives the possibility for simulation of the pre-crash-phase for a great number of real-world accidents and hence to assess active safety systems for a wide range of accident scenarios.
In the PCM a high number (currently more than 4000) of accidents are given and the use of the GIDAS database allows representative statements for the German accident scenario. The Number of accidents are increasing by and by.

LIST OF REFERENCES

[1] Dipl.-Ing.(FH) Christian Erbsmehl / Dr.-Ing. Lars Hannawald: Simulation realer Unfalleinlaufszenarien der German In-Depth Accident Study (GIDAS).

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