CONSIDERATION OF ACCIDENT AVOIDANCE TECHNOLOGY WITHIN GIDAS

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ABSTRACT

With GIDAS in summer 1999 a joint effort between FAT (Forschungsvereinigung Automobiltechnik or Automotive Industry Research Association) and BASt (Bundesanstalt für Straßenwesen or the Federal Highway Research Institute) started one of the largest in-depth accident data collection. Since then vehicles, objectives in road traffic policies etc. and following that also the accident data collection methods and research questions altered. While passive safety was the driving scheme in the accident data collection, accident causation, pre-crash manoeuvres and vehicle equipment with respect to accident avoidance technologies are crucial information to be gathered in modern field data collections.

During the time since its start the two GIDAS teams in Dresden and Hannover followed the new requirements and developed together with their sponsors methods to integrate the new research questions into the accident data investigation process. The new methods were reviewed after their implementation and further optimised if necessary based on lessons-learned. For example the involved car drivers were asked for each possible active safety system whether or not it was on board, activated and gave any feedback. Today it is known that the majority of car drivers is not familiar with the actual equipment of the own vehicle. In addition they mostly are only able to say that there was any kind of feedback from the car but they are normally unable to allocate the system to the feedback. Following that experience the drivers are now asked for the kind of feedback (audible, visual, haptic) rather than the system behind the feedback. The allocation of the responsible system for the feedback is now based on the expert judgement of the investigator based on the interview with the driver and the actual vehicle equipment.

Today GIDAS utilises psychological interviews in order to better understand the accident causation beyond legal implication as normally investigated by the police. The interview provides information of the movement of the accident involved parties for a period of 5 seconds before the initial impact in order to better understand the pre-crash phase and to evaluate different accident avoidance technology systems within the real accident environment. Based on a large number of variables for active safety systems it is furthermore possible to calculate accident risks for vehicles with and without a specific system as soon as a sufficient number of vehicles are equipped.

Although the GIDAS teams have been active in addressing future needs of accident data collection there are still open issues such as information of the actual performance of driver assistant systems. This would be even more important for self-driving vehicles.

INTRODUCTION

In-depth accident research has been a key input for improving road safety world-wide. While originally it was mainly focussed on passive safety research questions such as injuries, injury causation and accident severity in combination with passive safety features of vehicles, consideration of accident avoidance has been entered into in-depth accident research since the introduction of advanced driver assistance systems.

The German In-Depth Accident Study (GIDAS) was introduced in 1999 as a joint effort of the German Federal Highway Research Institute (BASt, Bundesanstalt für Straßenwesen) and the Common Research Association of the German Automotive Industry (FAT, Forschungsvereinigung Automobiltechnik). Being based on the experience of the Accident Research Unit in Hannover, that started in 1973, GIDAS progressively considere active safety research question in its investigation schemes.

This paper gives an overview of the GIDAS accident investigation scheme with focus on active safety features including example results.

GIDAS – German In-Depth Accident Study

In 1999 the German Federal Highway Research Institute (BASt, Bundesanstalt für Straßenwesen) and the Research Association of the German Automotive Industry (FAT, Forschungsvereinigung Automobiltechnik) founded in a joint effort the GIDAS in-depth accident collection project. GIDAS data are collected at the two locations Dresden and surrounding area in Saxony and Hannover and surrounding area in lower Saxony, see Figure 1. Both teams are collecting data according to the same sampling process and codebook. The study areas are nearly representative for Germany w.r.t. distribution of road types (i.e., highway, urban roads, rural roads etc.), accident severity and road user types.

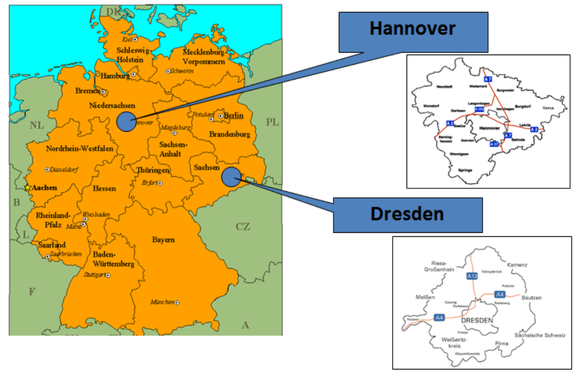

Figure 1. Locations of the two investigation areas.

Accidents are collected at 7 days per week in two alternating shifts per day. The alternating shifts are:

- week A: 0:00 – 6:00 and 12:00 – 18:00
- week B: 6:00 – 12:00 and 18:00 – 24:00

Within GIDAS road traffic accidents according to the German rules for road trafic accidents (i.e., accidents on publicly accessable roads or places involving at least one moving vehicle) with personal injury are collected. The teams are directly informed by the police and rescue teams about every road trafic accident with injured victims in order to be able to collect the data on the spot. In case more accidents in the individual shifts are happening than can be investigated, selection of the accident to be investigated is done based on a random selection process. Following that the GIDAS sample is nearly representative for the individual investigation zones and following the representativeness of the investigation areas for Germany also representative for the German accident situation. However, small differences to the German accident situation that is caused for example by an underreorting to the teams of accidents with slight injuries (mainly because these injuries are often reported to the police some time after the accident) and some other regional speciallities are observed. Weighting factors can be applied to project the GIDAS data to Germany.

In total approx. 2000 accidents are collected annually.

The collected data comprises information regarding up to 3000 individual technical, medical and psychological items including amongst others:

- Environmental conditions
- Road design
- Traffic control

- Accident details and cause of the accident
- Crash information e.g. driving and collision speed, delta-v and EES, degree of deformation
- Vehicle deformation
- Impact contact points for passengers or unprotected road users such as pedestrians and cyclists
- Technical vehicle data
- Information relating to the people involved such as weight, height etc.
- Information on individual injuries

An important item is the scaled sketch of the accident scene that is used for the accident reconstruction but more and more also for investigations of the pre-crash phase, see below.

The collected data is accessable for the GIDAS sponsors and the investigation teams

CONSIDERATION OF ACTIVE SAFETY AND AUTOMATED DRIVING

The GIDAS investigation teams in collaboration with the sponsors are continously updating the GIDAS investigation protocol in order to comply with future needs. These updates addresses in principle all areas of the investigation protocolls but with a special focus on accident avoidance technologies and a perspective towards automated vehicles.

Type of Accident

The first important step for consideration of active safety has already been done before establishing GIDAS by the introduction of the Type of Accident that describes the initial conflict causing the accident [1]. The Type of Accident is used with 7 categories in the German national accident statistics and with a variety of sub categories in some German states and in GIDAS amongst others. While in the seven main categories a distingtion is made for pedestrians crossing the road, vehicles crossing, vehicles turning of a road etc, in the subcetgories further information is coded e.g., whether or not there was a view blocking to the crossing pedestrian, in which direction the participants moved etc.

Coding of Vehicle Configuration

Since a variety of active safety features such as ABS, ESC, automated emergency braking systems, a diversity in vehicle lighting etc. became broadly available in new vehicles the actual availability of these systems are coded for each individual accident involved participant including information whether or not the individual systems were active and reacted in the individual accident. The coding of the availability of safety systems is based on vehicle inspection and VIN (Vehicle Identification Number) based query of vehicle data bases. Information on status of the systems and feedback is collected by interviews.

Pre-Crash Matrix

A very important further step was the development of the Pre-Crash Matrix (PCM) by the Dresden GIDAS team [2][3][4].

GIDAS information initially started at the time of collision and was projected to the point of no return. However, for assessing the benefits of active safety systems it is necessary to go back some seconds in the history of the accidents in order to be able to check, which information was available for the system to be assessed, see Figure 2. For relevant cases with sufficient information the movements of the involved participants are simulated for a period of 5 seconds before the intial impact or leaving the road etc. The PCM ingredients are a digital sketch of the accident, including the road layout, the driving courses of the opponents, amongst others (Figure 3), the vehicle dynamics of the opponents (i.e. velocity in longitudinal and lateral direction, acceleration in longitudinal and lateral direction, global yaw angle, steering angles of both front wheels, etc.) and static information of the vehicles, such as dimensions, wheel base, track width etc.

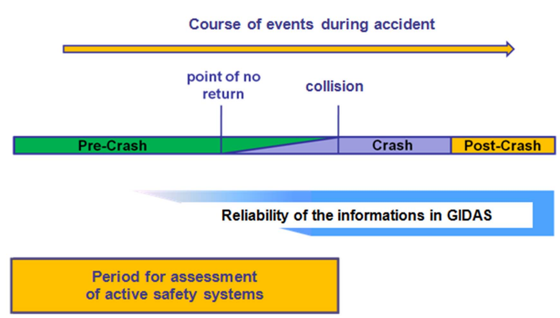

Figure 2. Phases of accident events [3].

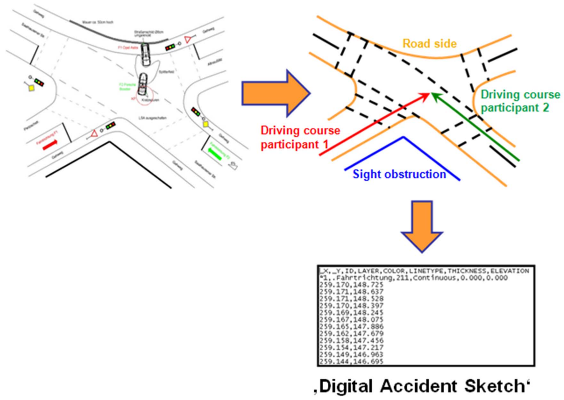

Figure 3. Phases of accident events [3].

Up to now the PCM data base is connected with but separate from the GIDAS data base. That means that not all organisations that have access to GIDAS have also access to the PCM data set. In addition not all GIDAS cases are included in the PCM data set. The selection of cases for inclusion considers the available input data of the GIDAS reconstruction (e.g., if it was not possible to assess the initial speed of the participants it is not possible to include the case for the PCM data set); the interest of the PCM users especially with respect to future active safety applications (bicycle-pedestrian accidents and bicycle single accidents will likely not be possible to address with active safety systems); simulation boundary conditions (e.g., it is currently impossible to use the data set for impacts that are outside the main vehicle geometry such as opened vehicle doors, impacts with the mirrors etc. and therefore the cases are not included). The current PCM data set includes with the release 2016-2 8,293 accidents with a distribution of cases according to Figure 4.

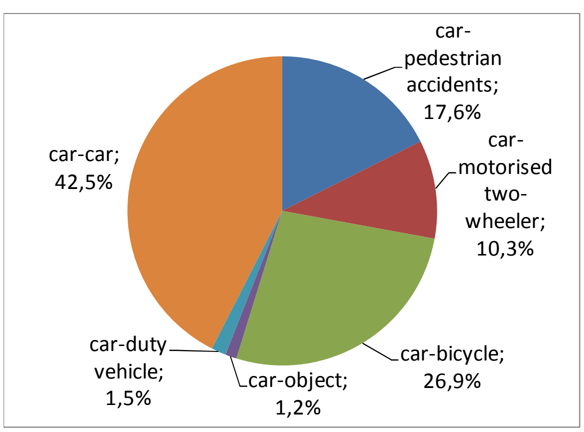

Figure 4. Case selection for the PCM data set by release 2016-2.

The Pre-Crash-Matrix is also continuously improving in details. More details on the newest developments are available at [6].

With the accident year 2017 the PCM became part of the GIDAS data set with updates on the requirements for accuracy and information depths. Furthermore it is planned to develop a data format for the PCM that is compatible with driving simulators.

Accident Causation

Accident causes are regularly coded by the police. This information mainly answers the question which traffic rule has been offended for legal purposes. However, in order to understand the actual accident causation it is important to know why the traffic rule has been offended. For example the police accident cause for an accident of two crossing vehicles could be “not respecting red light”. It is expected that the majority of people that are not respecting red lights are not acting on purpose but other factors such as distraction, view blocking, misjudgement lead to the wrong behaviour. This information is also important for assessing the possible contribution of accident avoidance systems. For example a system that is only warning would not help for accidents that are caused by temporary inability to operate the vehicle or for people that recognised the danger but felt that their behaviour was correct and the other one was wrong. This information based on a phsychological interview [5] is included in the GIDAS data base since 2008.

FUTURE DEVELOPMENTS

For further apaptations of the GIDAS system for addressing accident avoidance systems and automated vehicles it is planned to distinguish between actions that are taken by the driver and actions that are taken by the car itself. This change is planned already for 2018.

Furthermore it is planned to obtain access to the data stored in the car in order to have reliable information about warnings and actions of the car etc.

In addition to the further developments w.r.t. active safety and automation GIDAS is also looking for increased details w.r.t. injury consequences by the investigation of long-term consequences [6].

BASIC GIDAS ANALYSIS

For the following analysis unweighted data is used. The GIDAS data set (release December 2016) contains in total 30533 accidents ready for analyses. The distribution of the accidents regarding daytime and location of the accident are shown in Table 1.

Table 1.
Distribution of GIDAS accidents concerning daytime and location.

	day	twilight	night	total
inside city limits	18,058	1,837	3,839	23,734
outside city limits	4,657	634	1,508	6,799
total	22,715	2,471	5,347	30,533

Traffic Participation

In these 30,533 accidents 59,040 participants were involved. With 35,782 the majority of involved participants are passenger cars followed by bicycles, pedestrian and motorised two-wheelers, see Figure 5.

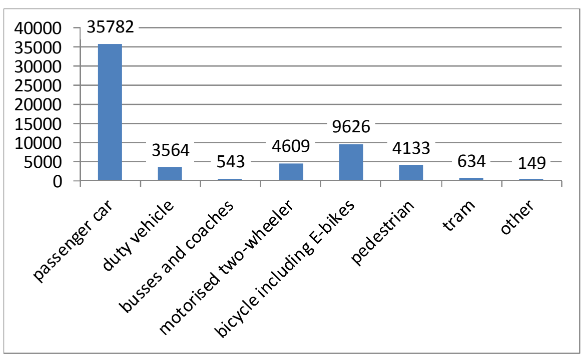

Figure 5. Road user types in the GIDAS sample.

Vehicle First Year of Registration

Especially for passenger cars and duty vehicles the year of first registration is relevant for taking into account legal requirements for the cars and consumer expectations w.r.t vehicle safety. Figure 6 shows the percentage of groups of specific first registrations years. The groups are built to include important dates (e.g., all passenger cars with year of first registration 2004 and later are obliged to fulfill UNECE regulations 94 and 95). Vehicles with year of first registration 2013 and later are considered to demonstrate the state of the art of the current fleet.

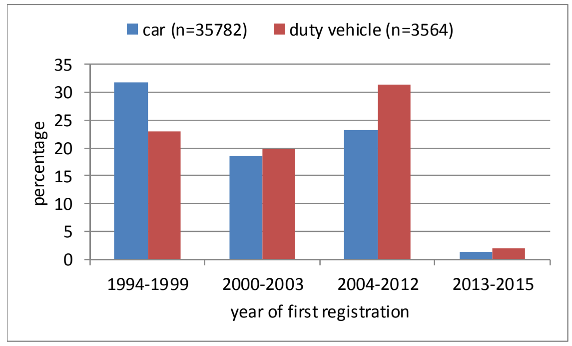

Figure 6. Year of first registration of vehicles in the GIDAS data base.

Active Safety Systems Fitment

Especially the availability of driver assistant systems is an important item to be considered for active safety evaluation. Most of the variables for analyzing driver assistant systems were introduced 2005. Therefore the analysis considers accidents since this year only. The fitment rate for completed accident files of accidents since 2005 is 41% of all involved passenger cars, see Table *2*. The systems brake assistant and any kind of support for maintaining the lane or changing the lane were introduced in the marked much later than ESC, which is also visible by the fitment rates of 28.4% for brake assistant system and below 1% for the lane assistant systems.

Table 2.
Car fitment with specific driver assistant systems

System	Fitment percentage in accidents since 2005
ESC	41.0%
Brake assistant	28.4%
Lane assistant systems including lane departure warning, lane keeping assistant etc.	0.8%

Type of Accident

The most important type of accident for cyclists using the bicycle path is the type crossing accident. Here especially accidents with a vehicle that is crossing the road or entering it and the cyclists is using the nearside cycle path is common. The detailed type of accident is shown in Table 3.

Table 3.
Most important type of accident for cyclists using the bicycle path

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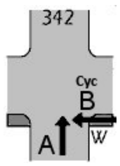
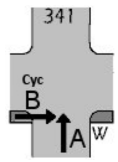
<tr><td>
</td><td>
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<tr><td>12% of all bicycle accidents</td><td>5% of all bicycle accidents</td></tr>
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Injuries

Injury severity is mainly analysed using the AAAM AIS codes. Most of the GIDAS users are analyzing slightly different body regions than according to the AIS codebook. For example head and face are normally analysed as one body region. Furthermore the clavicle is normally considered as a part of the thorax. However, it is also possible to analyse the data according to the AIS body regions and to obtain an ISS.

Table 4.
Injured body regions all accident involved causalities

Body region	all injuries	AIS 3+
head including face	13,501 (17.8%)	956 (1.3%)
neck including cervical spine	10,795 (14.2%)	201 (0.3%)
thorax including clavicle and thoracic spine	11,647 (15.4%)	1,075 (1.4%)
arms	13,672 (18.0%)	62 (0.1%)
abdomen	3,105 (4.1%)	269 0.4%)
pelvis	3,468 (4.6%)	205 (0.3%)
legs	15,883 (20.9%)	1,023 (1.3%)

Table 4 shows the distribution of injuries for the different body regions for all included causalities. Legs, arms and head are injured most often. When looking at AIS 3+ injuries only thorax, arms and head are the most often injured body regions. For this analysis it is important to consider, that vehicle occupants remain often uninjured, e.g., in accidents with pedestrians and cyclists. Therefore the number of injured causalities is relatively low when considering all accidents.

When looking at car occupants only, neck, head and arms are injured most often, see Table 5. For AIS 3+ injuries the body regions thorax, head and legs sustain most often severe injuries.

Table 5.
Injured body regions car occupants

Body region	all injuries	AIS 3+
head including face	6,366 (12.5%)	372 (0.7%)
neck including cervical spine	9,043 (17.8%)	107 (0.2%)
thorax including clavicle and thoracic spine	6,723 (13.2%)	531 (1.0%)
arms	4,741 (9.3%)	19 (0.0%)
abdomen	1,705 (3.4%)	148 0.3%)
pelvis	1,108 (2.0%)	85 (0.2%)
legs	4,194 (8.3%)	296 (0.6%)

Following the sample criteria most of the pedestrians in the GIDAS data base are injured. Following that percentages of injuries to the specific body regions are higher for pedestrians than for car occupants (Table 5). Legs, head and arms are the body regions sustaining most often injuries. Severe injuries are located at legs, head and thorax.

Table 6.
Injured body regions pedestrians

Body region	all injuries	AIS 3+
head including face	1,932 (46.8%)	219 (5.3%)
neck including cervical spine	236 (5.7%)	29 (0.7%)
thorax including clavicle and thoracic spine	874 (21.2%)	190 (4.6%)
arms	1,588 (38.4%)	14 (0.3%)
abdomen	346 (8.4%)	14 0.3%)
pelvis	614 (14.9%)	64 (1.5%)
legs	2,451 (59.3%)	255 (6.2%)

Accident Causation

Looking at the accident causation factors they are different for different road user types, Figure 7. While for car drivers a wrong focus of attention (recognition error) or wrong assessment of other road users or the own vehicle (assessment error) lead to the majority of accidents for truck driver view obstructions (information access) and a wrong focus of attention are the main reasons. For users of motorized two-wheelers wrong assessment of the own vehicle (assessment error) and speeding (planning error) are important contributing factors. Cyclists are often expecting other road users to recognize them and prevent the accident (assessment errors) and are using wrong parts of the road (planning errors). For pedestrians wrong focus of attention (recognition error) distraction (observation error) and view blocking by parked vehicles etc. (information access) have a major influence on accident occurrence.

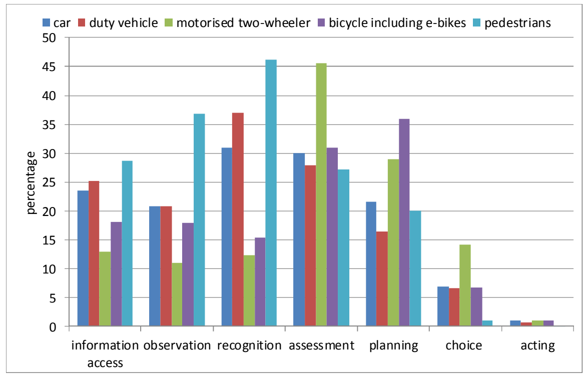

Figure 7. Human accident causes since 2011.

A selection of recent publications based on GIDAS is given by [8] - [13].

CONCLUSIONS

The GIDAS data base is a valuable instrument for analysing passive and more and more also active safety features of vehicles and infrastructure. The sponsors and the investigation teams are active in keeping the investigation frame up to date and to consider future needs for accident and safety research. Recent development and future plans consider vehicle dynamics, automated systems, phycology and a better understanding of consequences of accidents.

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