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69 Characteristics of Car Accidents in the Pre-Crash Phase

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Based on the material of about 1,600 car-to-car and single-car accidents, in which at least one person suffered MAIS 3+ injuries, and on a further material of approx. 950 accidents of young drivers with personal injury, a categorization of the accident circumstances and of pre-crash characteristics (for example loss of control, braking behavior etc.) took place. The analyses showed that loss of control and following crash - mostly side impact with traffic in opposite direction - has a much higher percentage in serious car-to-car accidents than assumed until today. Modern driver assistance systems, for example adaptive cruise control or electronic stability program, are expected not only to facilitate driving, but also to reduce accident risk. In comparison with the categorization of the pre-crash phase, an assessment is made which percentage of car-to-car and single-car crashes could be influenced by modern driver assistance systems in future.

Keywords: **Accident, Passenger Car, Skidding, Antiskid Device, Electronic Control / Driver Assistance System**

1. INTRODUCTION

Large-scale studies of automobile accidents involving personal injury, among other things, have been conducted in the past within the framework of accident research carried out by the German Insurance Association. The last such study entitled "Vehicle Safety 90" [1] emphasized global accident and injury as well as possible countermeasures. One principal result of this in-depth analysis of subset material relating to 1,111 car to car accidents with serious injury to the passengers (MAIS 3+) [2,3] was that almost 60 % of all passengers killed in accidents could be traced back to side-on collisions.

An in-depth analysis of side-on collisions showed that it is not accidents at intersections or junctions that predominate, but rather the most dangerous type of accident is one in which the car skids and, due to oversteering, is flung sideways into the opposite lane, causing a frontal/side-on collision there. In this type of accident, the passengers in the car that is hit on the side are very frequently killed [2]. The prevention of skidding by intelligent, technical systems is thus a high-priority measure.

The following study is intended to contribute to the systematic analysis of skid accidents, the characteristics that cause them to occur and possible approaches aimed at reducing the high risk of accidents that involve skidding.

2. DESCRIPTION OF MATERIAL AND METHOD

Defining the data material for such an accident study is extremely complex, since skidding can only be deduced from the sequence of events leading up to the accident, i.e. the skid marks or other evidence that is present (skidding off the road with/without steering back onto it). An **exact** reconstruction of the events is unfortunately impossible due to the lack of accident data storage system ("black boxes") in vehicles.

Representative database material with a sufficiently large number of cases does not yet exist in Germany. Although the official statistics [4] do provide information about the type and impact of accidents, they provide nothing that could be used to differentiate skid accidents.

2-1. Accident material: "Car Collisions of Young Drivers Involving Personal Injury"

GDV accident research, however, is based on accident material which does allow an estimate of the frequency of "car collisions with skidding in the pre-crash phase – at least for the special group of young drivers (from 18 to 24 years of age). **All** car accidents involving young drivers and personal injury in 1996, i.e. 936 accidents, were recorded for a clearly defined geographical area (the Traunstein police precinct).

The original objective of this study was to determine safety deficits of young drivers with an aim at improving driver training. However, since this study contains comprehensive statistics relating to car accidents involving young drivers, this accident material can also be used to determine the frequency of skid accidents. It must be taken into consideration, however, that skid accidents might occur more frequently in the case of young drivers than in the case of older, more experienced drivers.

2-2. Accident Material: "Car-to-Car and One-Car Accidents Involving Serious Injury" (RESIKO)

In order to supplement the comprehensive statistics in this clearly defined geographical region, two other accident databases were used for this paper, both of which involved without exception car accidents involving serious passenger injury (MAIS 3+). As far as the impact of injury is concerned (at least one passenger with MAIS 3+), these accident databases are homogeneous, although they cannot be extrapolated for the general sequence of events leading up to an accident in all points due to the selection criteria.

All those accidents that involved skidding and that contained confirmed information regarding the pre-crash phase were selected from a total of 1,111 car-to-car and 524 single-car accidents. The results of this selection were

- 131 car-to-car accidents (MAIS 3+) involving skidding and
- 200 single-car accidents (MAIS 3+) involving skidding.

These figures are used as the basis of the results in section 4-2.

The present study is a pilot study which in the future will have to be supplemented and expanded as new findings become available. The frequency data are not so much a precise determination of the exact percentage of "skid accidents in car collisions involving passenger injury", but rather a statement of a trend toward the global frequency of this type of accident.

This study already reveals important fundamental facts about the circumstances of accidents (type of skidding, braking reaction and the length of the critical path). These findings are intended to provide at least a starting point for the optimization of driver assistance systems and to make efficiency studies concerning dynamic electronic driving systems possible.

3. SYSTEMATIC CONSIDERATIONS

In this study, "skidding" is defined as any driving maneuver in which a critical range is exceeded [5]. Furthermore, a differentiation is made between simple skidding and multiple skidding. In the case of simple skidding, there is an initial interference or obstruction which causes the driver to swerve or steer in the opposite direction. A normal driver is usually incapable of correcting this swerving and loses control of the car. The car then turns sideways with an ensuing collision. Multiple skidding differs from the above and is considered to be those cases in which due to grooves in the road or at the edge of the roadway or based on the testimony of the persons involved in the accident, several steering attempts were made to stabilize the vehicle and that, towards the end of this phase of swinging back and forth, the driver finally lost control of the car which then turned sideways or even spun about its own axis. Based on the skid marks in the pre-crash phase and in part based on the testimony of the driver himself or the driver of the car behind him, it is possible to make statements about the braking reaction. Moreover, the length of the critical path can be estimated.

This information is of necessity cloaked in uncertainty which can only be avoided by using an accident data storage system ("black box").

4. RESULTS

4-1. Skid Accidents in the Accident Material "Car Collisions of Young Drivers With Personal Injury"

As mentioned in section 2 above, there is currently no representative material for drivers in **all** age classes, but only for young drivers between the ages of 18 and 24 (Chapter 2.1). Since skid accidents are probably more frequent among younger drivers than in the case of older drivers, the information below is more likely to represent an upper limit for the "skid accident risk".

Table 1 shows both the characteristics of the accident material with respect to the other party involved in the accident as well as a comparison with the official statistics [4].

Table 1: Accident opponent in the "young drivers" database and national statistics

	Database "Young Drivers"		National Statistics	
	n	%	n	%
single car accident	228	34.1	80542	24.5
car /car	313	46.9	161992	49.3
Truck / Bus	25	3.7	16143	4.9
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bicycle	38	5.7	29403	9.0
pedestrian	15	2.2	18788	5.7
total	668	100.0	328410	100.0

Car-to-car accidents show more or less the same frequency both in the accident material of young drivers and in the official statistics. Single-car accidents involving young drivers, on the other hand, are found much more frequently than in the average covering all drivers. This can be explained, among other things, by the fact that more than 86 % of all single-car accidents caused by young drivers occurred outside of town and were substantially higher than in the official national statistics (75 %).

The percentage of accidents at intersections/junctions amounted to 29.6 % and 19.9 % for rear-end accidents. Skid accidents amounted to 25.2 % and were usually caused by a mistake on the part of the driver. In 46.6 % of all skid accidents, the vehicle turned more than 90 degrees during the skidding phase. In 58 % of all single-car accidents, skidding was much more frequently involved than in car-to-car collisions (12.5 % skidding).

The characteristics of skidding with respect to the course of the road are shown in **Table 2**.

Table 2: Car-to-car and single-car accidents involving skidding illustrating how the car left the road

	single car accident					
	single skidding		several time skidding		total	
car leaves	n	%	n	%	n	%
straight road on right side	2	9.1	20	90.9	22	100.0
straight road on left side	12	52.2	11	47.8	23	100.0
curve on the inner side	39	75.0	13	25.0	52	100.0
curve on the out side	26	44.1	33	55.9	59	100.0
total	79	50.6	77	49.4	156	100.0

	car / car collision					
	single skidding		several time skidding		total	
car leaves	n	%	n	%	n	%
straight road on right side	1	50.0	1	50.0	2	100.0
straight road on left side	15	71.4	6	28.6	21	100.0
curve on the inner side	10	71.4	4	25.6	14	100.0
curve on the out side	28	65.1	15	34.9	43	100.0
total	54	67.5	26	32.5	80	100.0

	total	
car leaves	n	%
straight road on right side	24	10.2
straight road on left side	44	18.6
curve on the inner side	66	28.0
curve on the out side	102	43.2
total	236	100.0
curve on the inner side	66	39.3
curve on the out side	102	60.7
total	168	100.0

In accidents that occurred in curves, the vehicle left the road on the inside in 66 cases (39.3 %). This means that maximum transverse acceleration had not been achieved and the accident was thus due to oversteering and not to reaching the physical limit of transverse acceleration. In these cases, the vehicle could still have been kept under control as far as the physics of the vehicle is concerned. Table 2 also shows that a crisis suddenly developed in curves and even after brief single skidding a situation arose in which the driver lost control of the vehicle.

On straight roads, however, skidding tends to last longer and involve multiple attempts to correct the situation until the vehicle reaches that critical state in which the driver loses control of the vehicle.

4-2. Skid Accidents in the Accident Material "Car-to-Car and Single-Car Accidents Involving Severe Injury" (RESIKO)

Table 3 shows the accident characteristics relating to the course of the road for car-to-car and single-car accidents.

Table 3: Course of the road in skid accidents

	car / car accident		single car accident	
	n	%	n	%
straight road	41	31.3	86	43
curve right	38	29.0	51	25.5
curve left	52	39.7	63	31.5
total	131	100.0	200	100

It was found that – at least as far as the present accident material is concerned – single-car accidents are substantially more frequent (43 %) along straight stretches of road than car-to-car collisions (31.3 %).

Basically speaking, it was found in both sets of data (Chapter 2.2) that left-hand curves were involved in 31.5 % of all single-car accidents and in 39.7 % of all car-to-car collisions and thus were substantially more frequent than accidents in right-hand curves. This is probably due to the fact that in left-hand curves the driver very quickly reaches the edge of the road surface in the event of an uncontrollable critical situation. This requires immediate controlled action on the part of the driver, whereas in the case of right-hand curves at least some of the other lane is available to the driver for correction.

4-2-1. Frequency of Attempted Correction. Table 4 shows in relation to the course of the road whether single or multiple attempts were made to correct the car.

Table 4: Attempted corrections broken down according to the course of the road

	car / car accident					
correction attempts	single		multiple		total	
	n	%	n	%	n	%
straight road	18	43.9	23	56.1	41	100
curve right	11	28.9	27	71.1	38	100
curve left	4	7.7	48	92.3	52	100
total	33	25.2	98	74.8	131	100

	single car accident					
correction attempts	single		multiple		total	
	n	%	n	%	n	%
straight road	40	46.5	46	53.5	86	100
curve right	22	43.1	29	56.9	51	100
curve left	9	14.3	54	85.7	63	100
total	71	35.5	129	64.5	200	100

What is important is that multiple attempts at correction were made in 74.8 % of all car-to-car collisions and attempts were made in 64.5 % of single-car accidents at least. This means that a driver assistance system would have a relatively good chance of stabilizing the vehicle. The simple steering corrections (25.2 % and 35.5 %), however, illustrate that vehicle stabilization systems must take the problem of extreme oversteering (suddenly and excessively jerking the steering wheel around) into account.

4-2-2. Length of the Critical Path.- The length of the critical path – again broken down according to the course of the road – is presented in **Table 5**.

Table 5: Length of the critical path as a function of the course of the road

	car / car accident							
	< 40 m		40 - 70 m		> 70 m		total	
	n	%	n	%	n	%	n	%
straight road	3	7.3	27	65.9	11	26.8	41	100
curve right	7	18.4	27	71.1	4	10.5	38	100
curve left	9	17.3	28	53.8	15	28.9	52	100
total	19	14.5	82	62.6	30	22.9	131	100

	single car accident							
	< 40 m		40 - 70 m		> 70 m		total	
	n	%	n	%	n	%	n	%
straight road	23	26.7	35	40.7	28	32.6	86	100
curve right	8	15.7	33	64.7	10	19.6	51	100
curve left	9	14.3	43	68.2	11	17.5	63	100
total	40	20	111	55.5	49	24.5	200	100

The unanimous result for car-to-car and single-car accidents is that critical paths of 70 meters and more on a straight road had a frequency of 26.8 % and 32.6 %. In at least another 40 % (single-car accidents) or 65.9 % (car-to-car collisions), the length of the critical path ranged from 40 to 70 meters. Whereas extremely short critical paths were relatively rare in 7 % of all car-to-car collisions, this is more frequently the case (27 %) in single-car accidents.

It is possible to use the frequency of attempted corrections and an estimation of the length of the critical path as a basis for gauging for accidents that occur on straight roads. In at least 50 % of all skid accidents, the chances of minimizing or correcting the path of the vehicle would have been good for a dynamic vehicle stabilization system. In the current evaluation phase, it is not possible to correlate these factors with the speed the car was travelling, although such a study is scheduled for the future.

The length of the critical path in curves is shorter than along a straight stretch of road. Nonetheless, the result is that the length of the critical path exceeded 70 meters in approximately 10 % to 30 % of all accidents, and that in approximately 55 % to 70 % of all accidents the length of the critical path still ranges between 40 and 70 meters. Extremely short critical paths of less than 40 meters existed in less than 20 % of all accidents. An earlier study of single-car accidents [6] already led to similar results.

4-2-3. Frequency of Braking.- The occurrence of a simultaneous braking reaction has considerable impact on the efficiency on the one hand and the requirements on the other that must be expected of dynamic electronic braking systems. There is amazing concurrence between the independent data subsets in single-car and car-to-car accidents.

In the case of skid accidents along a straight stretch of road, the driver failed to apply the brakes in 43.9 % and 44.8 % of all accidents (**Table 6**).

Table 6: Braking as a function of the course of the road

	car / car accident							
	without		partial breaking		full breaking		total	
	n	%	n	%	n	%	n	%
straight road	18	43.9	5	12.2	18	43.9	41	100
curve right	18	47.4	7	18.4	13	34.2	38	100
curve left	28	53.8	4	7.7	20	38.5	52	100
total	64	48.9	16	12.2	51	38.9	131	100

	single car accident							
	without		partial breaking		full breaking		total	
	n	%	n	%	n	%	n	%
straight road	26	44.8	9	15.5	23	39.7	58	100
curve right	16	47.1	8	23.5	10	29.4	34	100
curve left	30	54.6	13	23.6	12	21.8	55	100
total	72	49	30	20.4	45	30.6	147	100

This means that the driver attempts to stabilize the vehicle using the steering wheel alone. Braking with locked wheels accounted for 43.9 % of all car-to-car collisions and 39.7 % of all single-car accidents. In the situation of the single-car accident, the driver attempted "to stabilize the vehicle by at least partially applying the brakes" in at least 15 % of all cases.

In curves, the percentage of braking with locked wheels is even lower, in particular in the case of single-car accidents. Just as in the case of skid accidents on straight roads, on-coming traffic (i.e. the threat of a car-to-car collision) appears to more frequently force the driver to brake with locked wheels, whereas this is much less common prior to a single-car accident, the driver normally attempting to stabilize the vehicle by partially applying the brakes. One completely concurrent result of the braking behavior in curves is that the driver fails to apply the brakes in about 45 % of all single-car accidents and 55 % of all car-to-car accidents, the driver attempting to stabilize the vehicle merely by correcting the path of the vehicle using the steering wheel.

5. SUMMARY

The critical situation of "skidding in the pre-crash phase" occurs much more frequently than previously assumed (a total of about 25 % of all accidents involving personal injury). For instance, 13 % of all car-to-car collisions and 58 % of all single-car accidents involving young drivers can be traced back to skidding. Three-quarters of these cases of skidding are caused by inattentiveness or a mistake on the driver's part; approximately one-quarter can be attributed to taking evasive action in an emergency situation.

Side-on collisions which today account for almost 60 % of all collisions involving passenger fatalities can frequently be traced back to skidding. In these instances, the driver cannot compensate for a sudden evasive movement or oversteering the vehicle and stabilize the vehicle. The vehicle then collides sideways either with other on-coming vehicles or against obstacles at the edge of the road such as trees, etc.

One characteristic of the pre-crash situations which is relevant to skidding was extrapolated from practical data in the present study. It was found that there was a critical path which ranged between 40 and 70 meters in approximately two-thirds of all cases and a critical path that even exceeded 70 meters in another 20 % of all accidents. Very short critical paths were found in only one out of five to six accidents that involved skidding. Dynamic electronic braking systems such as ESP antiskid devices would therefore provide valuable assistance for the driver in stabilizing the vehicle and would clearly reduce the number of accidents involving skidding, insofar as the drivers do not change their behavior behind the wheel.

The length of the critical path in curves is somewhat shorter than along straight stretches of road. It is characteristic that the driver does not simultaneously apply the brakes in approximately 45 % of all accidents that occur on straight roads, nor even in 55 % of all accidents that occur in curves. On the contrary, the driver attempts to stabilize the vehicle using the steering wheel only. Under these circumstances, the dynamic electronic braking system has a good chance to help stabilize the vehicle by acting on the individual wheels.

Dynamic electronic braking systems, however, are not only advantageous as far as accident prevention and active safety are concerned, but also in view of passenger safety and passive safety are concerned. Even if a collision is no longer avoidable, a stabilization system increases the likelihood of a collision with the front of the vehicle since the vehicle will be kept "on course" as far as possible, thus at least reducing the possibility of skidding sideways. This could considerably reduce the high percentage of side-on collisions which are extremely dangerous to car passengers.

These results are all based on three independent sets of accident data comprising approximately 1600 car-to-car and single-car accidents involving serious passenger injury and approximately 950 car accidents involving young drivers. The systematic analysis used in this study has proved to be practicable. This material will be expanded in greater detail and used for other topical accident data and in the correlation of accident parameters.

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total	54	67.5	26	32.5	80	100.0

	total	
car leaves	n	%
straight road on right side	24	10.2
straight road on left side	44	18.6
curve on the inner side	66	28.0
curve on the out side	102	43.2
total	236	100.0
curve on the inner side	66	39.3
curve on the out side	102	60.7
total	168	100.0

In accidents that occurred in curves, the vehicle left the road on the inside in 66 cases (39.3 %). This means that maximum transverse acceleration had not been achieved and the accident was thus due to oversteering and not to reaching the physical limit of transverse acceleration. In these cases, the vehicle could still have been kept under control as far as the physics of the vehicle is concerned. Table 2 also shows that a crisis suddenly developed in curves and even after brief single skidding a situation arose in which the driver lost control of the vehicle.

On straight roads, however, skidding tends to last longer and involve multiple attempts to correct the situation until the vehicle reaches that critical state in which the driver loses control of the vehicle.

4-2. Skid Accidents in the Accident Material "Car-to-Car and Single-Car Accidents Involving Severe Injury" (RESIKO)

Table 3 shows the accident characteristics relating to the course of the road for car-to-car and single-car accidents.

Table 3: Course of the road in skid accidents

	car / car accident		single car accident	
	n	%	n	%
straight road	41	31.3	86	43
curve right	38	29.0	51	25.5
curve left	52	39.7	63	31.5
total	131	100.0	200	100

It was found that – at least as far as the present accident material is concerned – single-car accidents are substantially more frequent (43 %) along straight stretches of road than car-to-car collisions (31.3 %).

Basically speaking, it was found in both sets of data (Chapter 2.2) that left-hand curves were involved in 31.5 % of all single-car accidents and in 39.7 % of all car-to-car collisions and thus were substantially more frequent than accidents in right-hand curves. This is probably due to the fact that in left-hand curves the driver very quickly reaches the edge of the road surface in the event of an uncontrollable critical situation. This requires immediate controlled action on the part of the driver, whereas in the case of right-hand curves at least some of the other lane is available to the driver for correction.

4-2-1. Frequency of Attempted Correction.

Table 4 shows in relation to the course of the road whether single or multiple attempts were made to correct the car.

Table 4: Attempted corrections broken down according to the course of the road

	car / car accident					
correction attempts	single		multiple		total	
	n	%	n	%	n	%
straight road	18	43.9	23	56.1	41	100
curve right	11	28.9	27	71.1	38	100
curve left	4	7.7	48	92.3	52	100
total	33	25.2	98	74.8	131	100

	single car accident					
correction attempts	single		multiple		total	
	n	%	n	%	n	%
straight road	40	46.5	46	53.5	86	100
curve right	22	43.1	29	56.9	51	100
curve left	9	14.3	54	85.7	63	100
total	71	35.5	129	64.5	200	100

What is important is that multiple attempts at correction were made in 74.8 % of all car-to-car collisions and attempts were made in 64.5 % of single-car accidents at least. This means that a driver assistance system would have a relatively good chance of stabilizing the vehicle. The simple steering corrections (25.2 % and 35.5 %), however, illustrate that vehicle stabilization systems must take the problem of extreme oversteering (suddenly and excessively jerking the steering wheel around) into account.

4-2-2. Length of the Critical Path.-

The length of the critical path – again broken down according to the course of the road – is presented in **Table 5**.

Table 5: Length of the critical path as a function of the course of the road

	car / car accident							
	< 40 m		40 - 70 m		> 70 m		total	
	n	%	n	%	n	%	n	%
straight road	3	7.3	27	65.9	11	26.8	41	100
curve right	7	18.4	27	71.1	4	10.5	38	100
curve left	9	17.3	28	53.8	15	28.9	52	100
total	19	14.5	82	62.6	30	22.9	131	100

	single car accident							
	< 40 m		40 - 70 m		> 70 m		total	
	n	%	n	%	n	%	n	%
straight road	23	26.7	35	40.7	28	32.6	86	100
curve right	8	15.7	33	64.7	10	19.6	51	100
curve left	9	14.3	43	68.2	11	17.5	63	100
total	40	20	111	55.5	49	24.5	200	100

The unanimous result for car-to-car and single-car accidents is that critical paths of 70 meters and more on a straight road had a frequency of 26.8 % and 32.6 %. In at least another 40 % (single-car accidents) or 65.9 % (car-to-car collisions), the length of the critical path ranged from 40 to 70 meters. Whereas extremely short critical paths were relatively rare in 7 % of all car-to-car collisions, this is more frequently the case (27 %) in single-car accidents.

It is possible to use the frequency of attempted corrections and an estimation of the length of the critical path as a basis for gauging for accidents that occur on straight roads. In at least 50 % of all skid accidents, the chances of minimizing or correcting the path of the vehicle would have been good for a dynamic vehicle stabilization system. In the current evaluation phase, it is not possible to correlate these factors with the speed the car was travelling, although such a study is scheduled for the future.

The length of the critical path in curves is shorter than along a straight stretch of road. Nonetheless, the result is that the length of the critical path exceeded 70 meters in approximately 10 % to 30 % of all accidents, and that in approximately 55 % to 70 % of all accidents the length of the critical path still ranges between 40 and 70 meters. Extremely short critical paths of less than 40 meters existed in less than 20 % of all accidents. An earlier study of single-car accidents [6] already led to similar results.

4-2-3. Frequency of Braking.-

The occurrence of a simultaneous braking reaction has considerable impact on the efficiency on the one hand and the requirements on the other that must be expected of dynamic electronic braking systems. There is amazing concurrence between the independent data subsets in single-car and car-to-car accidents.

In the case of skid accidents along a straight stretch of road, the driver failed to apply the brakes in 43.9 % and 44.8 % of all accidents (**Table 6**).

Table 6: Braking as a function of the course of the road

	car / car accident							
	without		partial breaking		full breaking		total	
	n	%	n	%	n	%	n	%
straight road	18	43.9	5	12.2	18	43.9	41	100
curve right	18	47.4	7	18.4	13	34.2	38	100
curve left	28	53.8	4	7.7	20	38.5	52	100
total	64	48.9	16	12.2	51	38.9	131	100

	single car accident							
	without		partial breaking		full breaking		total	
	n	%	n	%	n	%	n	%
straight road	26	44.8	9	15.5	23	39.7	58	100
curve right	16	47.1	8	23.5	10	29.4	34	100
curve left	30	54.6	13	23.6	12	21.8	55	100
total	72	49	30	20.4	45	30.6	147	100

This means that the driver attempts to stabilize the vehicle using the steering wheel alone. Braking with locked wheels accounted for 43.9 % of all car-to-car collisions and 39.7 % of all single-car accidents. In the situation of the single-car accident, the driver attempted "to stabilize the vehicle by at least partially applying the brakes" in at least 15 % of all cases.

In curves, the percentage of braking with locked wheels is even lower, in particular in the case of single-car accidents. Just as in the case of skid accidents on straight roads, on-coming traffic (i.e. the threat of a car-to-car collision) appears to more frequently force the driver to brake with locked wheels, whereas this is much less common prior to a single-car accident, the driver normally attempting to stabilize the vehicle by partially applying the brakes. One completely concurrent result of the braking behavior in curves is that the driver fails to apply the brakes in about 45 % of all single-car accidents and 55 % of all car-to-car accidents, the driver attempting to stabilize the vehicle merely by correcting the path of the vehicle using the steering wheel.

5. SUMMARY

The critical situation of "skidding in the pre-crash phase" occurs much more frequently than previously assumed (a total of about 25 % of all accidents involving personal injury). For instance, 13 % of all car-to-car collisions and 58 % of all single-car accidents involving young drivers can be traced back to skidding. Three-quarters of these cases of skidding are caused by inattentiveness or a mistake on the driver's part; approximately one-quarter can be attributed to taking evasive action in an emergency situation.

Side-on collisions which today account for almost 60 % of all collisions involving passenger fatalities can frequently be traced back to skidding. In these instances, the driver cannot compensate for a sudden evasive movement or oversteering the vehicle and stabilize the vehicle. The vehicle then collides sideways either with other on-coming vehicles or against obstacles at the edge of the road such as trees, etc.

One characteristic of the pre-crash situations which is relevant to skidding was extrapolated from practical data in the present study. It was found that there was a critical path which ranged between 40 and 70 meters in approximately two-thirds of all cases and a critical path that even exceeded 70 meters in another 20 % of all accidents. Very short critical paths were found in only one out of five to six accidents that involved skidding. Dynamic electronic braking systems such as ESP antiskid devices would therefore provide valuable assistance for the driver in stabilizing the vehicle and would clearly reduce the number of accidents involving skidding, insofar as the drivers do not change their behavior behind the wheel.

The length of the critical path in curves is somewhat shorter than along straight stretches of road. It is characteristic that the driver does not simultaneously apply the brakes in approximately 45 % of all accidents that occur on straight roads, nor even in 55 % of all accidents that occur in curves. On the contrary, the driver attempts to stabilize the vehicle using the steering wheel only. Under these circumstances, the dynamic electronic braking system has a good chance to help stabilize the vehicle by acting on the individual wheels.

Dynamic electronic braking systems, however, are not only advantageous as far as accident prevention and active safety are concerned, but also in view of passenger safety and passive safety are concerned. Even if a collision is no longer avoidable, a stabilization system increases the likelihood of a collision with the front of the vehicle since the vehicle will be kept "on course" as far as possible, thus at least reducing the possibility of skidding sideways. This could considerably reduce the high percentage of side-on collisions which are extremely dangerous to car passengers.

These results are all based on three independent sets of accident data comprising approximately 1600 car-to-car and single-car accidents involving serious passenger injury and approximately 950 car accidents involving young drivers. The systematic analysis used in this study has proved to be practicable. This material will be expanded in greater detail and used for other topical accident data and in the correlation of accident parameters.

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