REAL WORLD SAFETY BENEFITS OF BRAKE ASSISTANCE SYSTEMS

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Paper Number 07-0103

ABSTRACT

The first brake assist system (BAS) was developed by Mercedes-Benz and introduced in 1996. It has been a standard feature on all Mercedes-Benz passenger cars since 1997. Recent statistical analyses of German accident data show significant safety benefits of this technology: Both the percentage of severe accidents involving pedestrians as well as the rate of rear end collisions are lower for vehicles equipped with BAS than vehicles without BAS. The conventional brake assist (BAS) is now completed by radar based adaptive brake assistance functions (BAS PLUS and PRE-SAFE® Brake) which have demonstrated their benefits both in internal and external tests.

FOCUSSING ON REAR-END COLLISIONS

The European Commission has set an ambitious goal for road safety in Europe: The road safety action programme aims at reducing the number of fatalities by 50% in the period from 2000 to 2010. The interim result for Germany is promising: Between 2000 and 2005, the number of fatalities was reduced by 29% in spite of a fleet increase of 6%. The last decade has seen a decrease in fatalities of 43% in Germany. While these improvements can be attributed to a variety of factors, advanced vehicle safety technology certainly plays a major role.

Having addressed the problem of loss of control-accidents very successfully by the introduction of ESP® [1], [2] which has been a standard feature in all passenger vehicles since 1999, Mercedes-Benz safety engineering focuses on avoiding and mitigating rear-end collisions. In Germany all accidents caused by conflicts between road users moving into the same or in the opposite direction („Unfall im Längsverkehr“) accounted for 21 percent of all fatalities and 17 percent of all severe injuries in 2005. In this category, collisions with another vehicle or with an obstacle on the road accounted for 470 fatalities and 8.611 severely injured persons [3].

The following main causal factors for these accidents are derived from in-depth accident analyses:

- Driver’s braking reaction comes too late.
- Driver’s braking reaction is not vigorous enough.
- Misinterpretation of the traffic situation by the driver, especially regarding the deceleration of the preceding vehicle

BRAKE ASSIST (BAS)

Function

It was in the early 1990s that Mercedes engineers conducting tests in the driving simulator found that while the majority of male and female drivers operate the brake pedal rapidly in an emergency situation, they often do not do so with sufficient force. The technical braking performance is therefore not used to the full, and the braking distance is considerably increased. These findings led to the development of the Brake Assist System (BAS) which supports drivers who apply the brake pedal quickly but not vigorously enough by directing maximum power assist to the brakes in emergency situations [4].

The system uses pedal application speed as an indicator for emergency situations. If an unusually high pedal speed is registered, the system infers an emergency braking situation and automatically increases the pressure in the wheel brake cylinders (see Figure 1). During this automatic full-force braking, wheel lock is prevented by ABS. If the driver takes his foot off the brake pedal, the automatic brake boosting is immediately terminated.

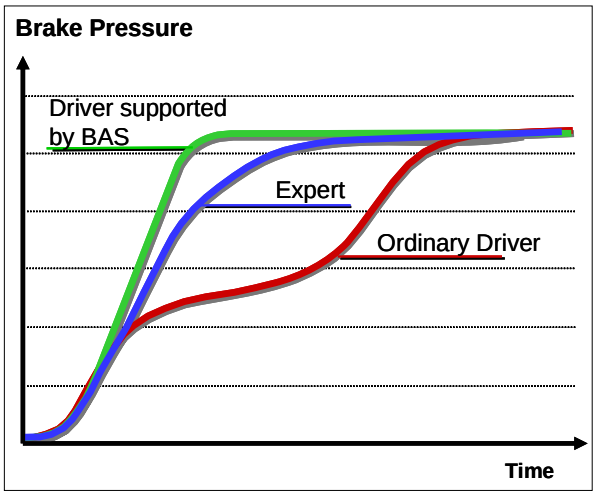

Figure 1. Illustration of typical brake pressure build-up in an emergency situation for ordinary drivers, driving experts and drivers supported by Brake Assist System (BAS).

This assistance system was invented by Mercedes-Benz, first introduced in 1996 and became a standard feature in all Mercedes-Benz passenger cars in 1997.

Benefits for Pedestrian Protection

Tests with ordinary drivers on a test track demonstrated that BAS contributes to a significant reduction in stopping distance by up to 45 percent on a dry road surface. In addition, tests in the Berlin dynamic driving simulator showed that this system is also a valuable contribution to pedestrian protection [5]: In a typical accident scenario, i.e. a child suddenly crossing the street in an urban area, the accident rate was significantly lower for subjects who drove with BAS (accident rate 32 percent) vs. subjects who did not have this assistance system (accident rate 58 percent).

Analysis of German Accident Data

The Federal Statistical Office Germany collects and processes data from all traffic accidents registered by the German police (e.g. 2.25 million accidents recorded in 2005). Since 1999 DaimlerChrysler annually obtains an anonymous sample of these accident data. Each sample contains 50% of all accidents with a certain severity (fine, injury) from the respective last two years. Among other variables, the samples contain data on accident type, year of the vehicle registration, vehicle category, model information for vehicles of DaimlerChrysler AG brands only, and classes of weight-to-power ratio for other brand models. The time of the accident is defined by the period of the samples. Each sample consists of more than 500.000 cases from the respective last two accident years. Hence, the annually obtained samples are overlapping regarding the accident year (e.g. the sample obtained in 2001 consists of accidents occurred in the years 1999 and 2000).

Pedestrian Protection The percentage of severe accidents (accidents involving fatalities or severe injuries) of all accidents involving pedestrians was calculated for vehicles registered between 1995 and 1997 vs. vehicles registered between 1998 and 2000. This percentage remains constant for competitors‘ vehicles but decreases for newer MB-vehicles which were all fitted with BAS as a standard feature (see Figure 2).

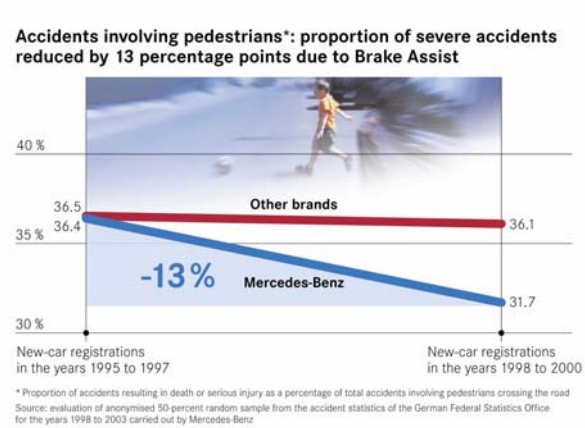

Figure 2. Fewer severe accidents for vehicles equipped with Brake Assist System (BAS)

<u>Rear-End Collisions</u> – The rate of rear-end collisions caused per 10.000 newly registered vehicles was calculated for vehicles registered in 1996-1997 which were involved in an accident in 1998 or 1999 and compared to the rate for vehicles registered 1997-1998 which were involved in an accident in 1999 or 2000 (see Figure 3). Whereas this rate remains constant fort he other brands, it shows a reduction for Mercedes-Benz passenger cars which is mainly attributed to the presence of BAS in Mercedes-Benz cars registered 1997-1998 (BAS was made standard in 1997).

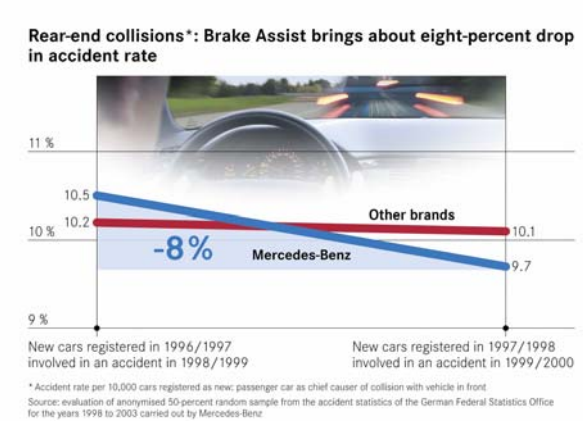

Figure 3. Newer Mercedes-Benz vehicles (equipped with BAS as standard feature) cause less rear-end collisions

ADAPTIVE BRAKE ASSISTANCE FUNCTIONS

Brake Assist PLUS

For the new S- and CL-Class, Mercedes-Benz has expanded Brake Assist into a preventive system which assists the driver even more effectively than before in critical situations. The Brake Assist PLUS system is based on radar technology: it registers the distance from detected vehicles ahead, warns the driver if the gap is too small and calculates the necessary brake force assistance if a rear-end collision threatens. If traffic tails back and the driver is obliged to operate the brake pedal, the new Brake Assist PLUS instantly builds up the braking pressure required to manage the situation.

While reflex-like operation of the brake pedal is necessary to activate the conventional Brake Assist System (BAS, which is still a part of the standard equipment), the new system already detects the driver's braking intention when the pedal is depressed and automatically optimises the brake pressure. This meets one of the major conditions for preventing rear-end collisions, namely the best possible deceleration for the situation in hand.

Preventive Brake Assist PLUS uses two radar systems to monitor the traffic situation ahead of the vehicle: a newly developed short-range radar based on 24-Gigahertz technology works together with the 77-Gigahertz radar of the DISTRONIC PLUS adaptive cruise control system. These systems complement each other: while the DISTRONIC radar is configured to monitor three lanes of a motorway to a range of up to 150 metres with a spread of nine degrees, the new 24-Gigahertz radar registers the situation immediately ahead of the vehicle with a spread of 80 degrees and a range of 30 metres.

Mercedes-Benz has intensively tested the effectiveness of this technology in the driving simulator and in practical trials: 110 male and female drivers took part in a series of tests in the driving simulator. They each had to cope with several typical critical situations on motorways and country roads derived from accident research. It was only possible to avoid accidents by hard braking. Thanks to the new Brake Assist PLUS system, the accident rate during this test series fell by three quarters compared to the

average of 44 percent with conventional brake technology only (see Figure 4).

The new technology demonstrated its advantages particularly well when driving in a line of traffic at 80 km/h on a country road: when the vehicle ahead was suddenly braked, the radar-based Brake Assist system prevented an accident in 93 percent of cases – while more than one in two test drives ended in a rear-end collision without the system. Even in situations where a collision was unavoidable owing to a late response by the driver, the new system helped to reduce the severity of the impact. This was confirmed by the measured impact speed, which was reduced from an average of 47 to 26 kph thanks to Brake Assist PLUS.

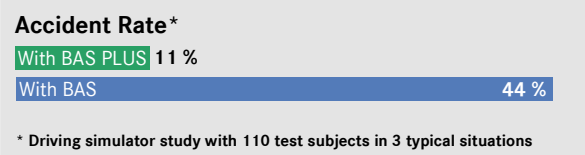

Figure 4. Results of dynamic driving simulator tests with 110 ordinary drivers: Accident Rate in 3 typical driving scenarios with high danger of rear-end collision

PRE-SAFE® Brake

Brake Assist PLUS is complemented by the system PRE-SAFE® Brake which goes one step further: If the driver does not react to the BAS PLUS warnings from the cockpit and the system detects a severe danger of an accident, the system triggers automatic partial braking and decelerates at up to 0.4 *g*. Autonomous partial braking provides the driver with a further clear prompt to take action, on top of the visual and audible warnings. If the driver immediately goes on to activate the brake, maximum braking force will be provided by BAS PLUS, and – depending on the given situation – it may be possible to prevent the accident at the last moment. If this is not possible, the PRE-SAFE® Brake system reduces the severity of the impact, which in turn reduces the risk of injury for the occupants of the car.

Since practice shows that drivers do not always react as quickly as is needed at critical moments – for example because they are distracted and fail to register the warning signals provided by Brake Assist PLUS, the newly developed PRE-SAFE® Brake intervenes in situations such as these, automatically braking if an acute danger of an accident is detected. The following timeline represents a typical rear-end collision situation:

- Around 2.6 seconds before the moment of impact calculated by the system the audible warning signal sounds. A red warning symbol in the instrument cluster also informs the driver that there is a danger of an accident.
- Approximately 1.6 seconds before the calculated accident – if the driver has not reacted to the warnings, the PRE-SAFE® Brake system activates autonomous partial braking.
- Around 0.6 seconds before the impact the driver has a final chance to avert the accident by swerving rapidly or applying full braking. This means that, after the PRE-SAFE® brake has intervened, the driver has around a second to act.

To assess the benefits of the new system 70 drivers took part in tests in the dynamic driving simulator in Berlin. The scenario involved the participants being deliberately distracted by an accident on the opposite driving lane while the queue of traffic in front suddenly braked at the same instant (see Figure 5).

Figure 5. Driving scenario used in dynamic driving simulator tests to deliberately distract subjects from primary driving task (car following scenario)

The results of the test, which reflects a real world situation, document the safety benefits offered by the radar based assistance systems: thanks to the rapid reactions of the drivers, and support from BAS PLUS and the PRE-SAFE® brake, a total of 70 percent of these test drives remained accident-free. In one third of the simulator tests the participants were unable to prevent a collision. Here automatic partial braking succeeded in reducing the severity of the accident by around 40 percent (see Figure 6).

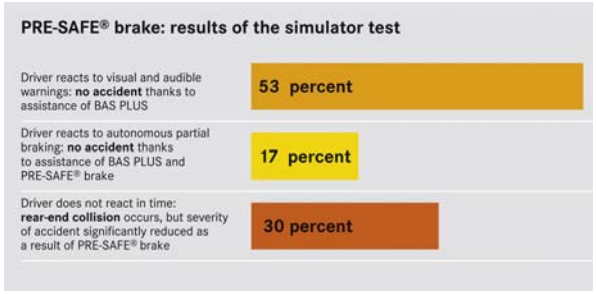

Figure 6. Results of dynamic driving simulator tests with deliberately distracted subjects in a car following scenario with sudden braking of lead vehicle

The PRE-SAFE® Brake system has also been tested thoroughly by the ADAC in 2006: Based on several tests on a test track as well as on crash tests, ADAC concluded the following safety benefits: In a specific accident situation PRE-SAFE® Brake reduced occupant load by 27 percent for the driver, by 30 percent for the front passenger and by 45 percent for the rear passenger [6].

CONCLUSIONS

Brake assistance systems contribute significantly both to the avoidance and the mitigation of rear-end collisions. Conventional brake assist systems such as the Merecdes-Benz BAS also contribute to pedestrian protection.

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