

## **ESF 2019 – EXPERIMENTAL SAFETY VEHICLE MEETS AUTOMATED DRIVING MODE**

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Paper Number 19-0042

### **ABSTRACT**

Since the early beginning of the Enhanced Safety Vehicle Program in 1969, Mercedes-Benz has created over 30 ESF cars, and thus played a key role in the development of modern automotive safety.

After more than 30 years Mercedes-Benz presented in 2009 a new ESF based on the very latest safety features, such as Advanced Driver Assistance Systems, Adaptive Restraint Systems, and Integrated Safety Systems (PRE-SAFE®)

Nowadays, the automotive industry is facing one of its most challenging paradigm shifts. In the coming years, connectivity, automated driving, shared services and electric cars will fundamentally change the usage of cars. After ten years Mercedes-Benz will show again a research car: the ESF 2019. Mercedes-Benz, as a worldwide leader in automotive safety, will demonstrate its vision and ideas for safety for this new vehicle generation: a vision of safety that goes beyond just the passenger and includes the vehicle's surroundings.

With all its innovations, the Mercedes-Benz Experimental Safety Vehicle 2019 represents a further milestone in automotive safety.

## HISTORY ESF@Mercedes-Benz:

### The genesis of Passive Safety

Passive Safety has a very long tradition at Mercedes-Benz, already before the foundation of the ESV program. One of the very first milestone of Passive Safety is surely the 23<sup>rd</sup> of January 1951, where Daimler-Benz AG registered a patent for the passenger car body with a passenger safety cell. This invention by Béla Barényi was granted Patent No. 845 157 with the title "Motor vehicle, specifically for personal transport". This was a trailblazing innovation, as it is still seen as the fundamental feature of passive automotive safety to this day. In 1959 the safety body with its rigid passenger cell entered series production for the first time in the Mercedes-Benz W 111 series (model 220b).

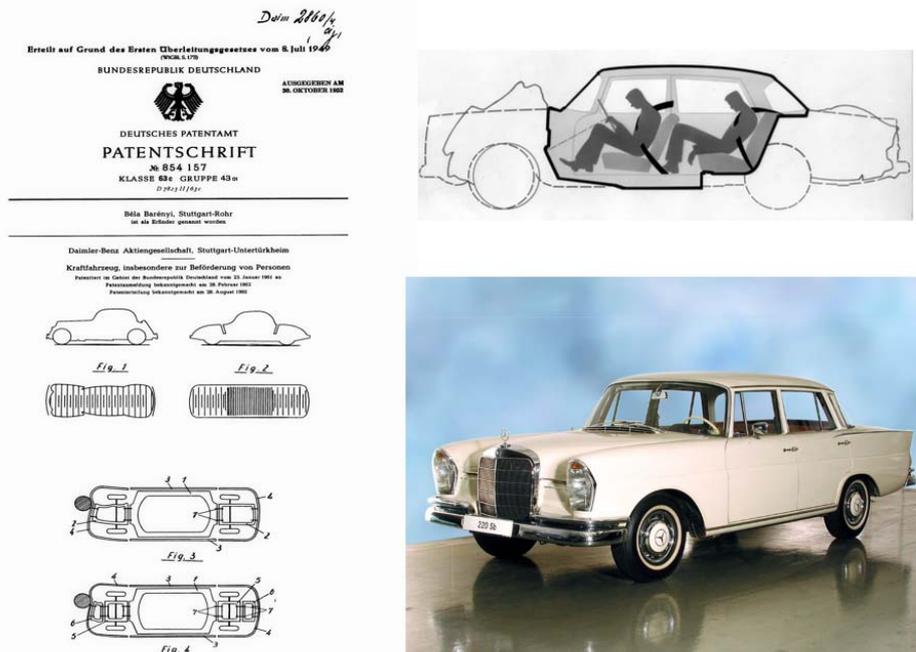


Fig. 1: Patent No. DBP 854 157, life-saver of thousands - the crumple-zone - Mercedes-Benz W111

### Mercedes-Benz Experimental Safety Vehicles

In the 1960s it became impossible to ignore a negative aspect of mass motorisation: more and more people were being killed on the roads. In 1968 the US Department of Transport therefore started a programme for the development of Experimental Safety Vehicles (ESVs), and initiated the international "Technical Conference on the Enhanced Safety of Vehicles". Two years later the specifications to be met by the ESVs were defined. The American government also issued an invitation to foreign countries to take part in this safety research. In 1970 this gave rise to the still active European Enhanced Vehicle Safety Committee (EEVC).

At Mercedes-Benz the challenge of designing vehicles with even more safety was taken up with great enthusiasm. After all, the company was already able to look back on more than 20 years of continual safety research at the time. MB has built a total of 35 ESF from the beginning of the program until today. Some major innovations were later introduced into production vehicles and have already been standard for years. Examples are ABS, belt tensioners and belt force limiters, airbag and side impact protection.

Mercedes-Benz presented the following four ESFs to the public, always as an input to the ESV conferences:



**Fig.2: ESF 5: developed on the basis of the W 114 (“Strich Acht”) series and presented at the 2nd International ESV Conference from 26 to 29 October 1971 in Sindelfingen**



**Fig.3: ESF 13: Stylistically revised variant of the ESF 5, presented at the 3rd International ESV Conference from 30 May to 2 June 1972 in Washington (USA)**



**Fig.4: ESF 22: Based on the W 116 series (1971 S-Class) and presented at the 4th International ESV Conference from 13 to 16 March 1973 in Kyoto (Japan)**



**Fig.5: ESF 24: Modified S-Class (W 116) presented at the 5th International ESV Conference from 4 to 7 June 1974 in London (Great Britain)**

Detailed specifications from the Mercedes-Benz ESVs can be found in [1]. The foundations for the current safety level of cars bearing the Mercedes star have therefore been laid. Extract from the summary test report (1975): "The ESF 24 can be regarded as the completion of the project, as this vehicle represents the best possible compromise between the original ESV requirements and our current series production cars."

At Mercedes-Benz safety was included in the development specifications for new cars as a matter of course decades before the ESV programme, and in rapid succession the ideas first realised as part of the ESF project entered series production as well. The milestones included:

- 1978: premiere of the ABS as an option for the S-Class
- 1980: driver airbag and belt tensioner available in the S-Class
- 1995: belt force limiters and sidebags enter series production of the E-Class

The ESV program was the starting point of modern safety. Over the years many additional safety features like passenger airbag or ESP were developed by Mercedes-Benz keeping alive the pioneering spirit of the ESV program.

#### **After 35 years finally another ESV: ESF 2009**

The ESF 2009 is the first Experimental Safety Vehicle Mercedes-Benz has built since 1974. Like its historic predecessors, it attractively combines trailblazing innovations in the field of safety and makes the progress achieved visible. The ESF 2009 was presented within the frame of the 21<sup>st</sup> ESV Conference from the 15 to 18 July 2009 in Stuttgart [2].



*Fig.6: The ESF 2009: Son and heir of a successful family*

The ESF 2009 aimed at demonstrating the safety benefit of the Integral Safety approach of Mercedes-Benz. This approach unites Active and Passive Safety and constitutes the foundation of the safety development for production cars. The Mercedes-Benz typical exemplary safety level is achieved when each of the 4 pillars of the integral safety approach reaches a high level. The following four phases describe the holistic safety approach:

- Safe driving: Provide safe driving environment with Intelligent Drive

- In detested critical driving situations: Assist with Intelligent Drive and prepare for a possible crash with PRE-SAFE®
- During a crash: Protect with sophisticated vehicle structures and adaptive restraint systems
- After a crash: Warn other road users and call for professional assistance if needed.



*Fig.7: The Integral Safety Strategy of Mercedes-Benz*

Core of the ESF 2009 are 13 safety innovations, which cover all the 4 pillars of the Integral Safety. One example for a system that addresses phase one is a new lighting system, the “Partial Main Beam” that allows the driver to leave the high beam constantly switched on while the oncoming or proceeding vehicle can be cut out. The 100 individually activated LED implemented in the headlight also enable the so-called spotlight function which allows potential hazard to be highlighted. Using a 360° sensor covering of the car surroundings, the ESF 2009 shows many new driver assistance systems such as Lane Keeping Assist, Blind Spot Assist and PRE-SAFE® Brake. The advanced radar sensors of the ESF 2009 allows the creation of very new preventive Safety Systems like PRE-SAFE® Pulse, PRE-SAFE® Structure and the Braking Bag. Braking Bag describes a special exterior airbag installed between the front axle carrier and the underbody paneling. If the sensor system concludes that an impact is inevitable, the Braking Bag is deployed just before the crash, supporting the car against the road surface by means of a friction coating. Activating this auxiliary brake in the vehicle floor improves both deceleration and compatibility with the other vehicle involved in the accident.



*Fig.8: Left: Headlight and Radar Sensors of the ESF 2009- Right: Braking Bag*

Even with this advanced sensor system, a collision still may be unavoidable. Therefore, the protection of the car passenger during a crash was also in focus of the car. Several Innovations like Beltbag, Size-Adaptive Airbag, Child Protect, Interseat Protection, ... provide the appropriate safety countermeasure for different collision scenarios.



**Fig.9: Some innovations of the ESF 2009: Child Protect, Beltbag and Interseat Protection**

Like for its predecessors, many innovations shown in the ESF 2009 already find their way into series production cars:

- 2012: Beltbag (S-Class W222)
- 2014: MULTIBEAM LED headlamps (CLS-Class C218)
- 2016: PRE-SAFE® Impulse Side in (E-Class W213)

As the name already suggests, the Beltbag is a combination of a seat belt and airbag. When the crash sensors detect a serious frontal impact, the airbag control unit activates the Beltbag along with the pyrotechnical pretensioner. This leads to the inflation of the double-layered belt that practically doubles its width within fractions of a second. This increase in the width of the belt spreads the load over a wider area, thereby reducing the risk of injury.

The innovation “partial main beam” from the ESF 2009 hit the market a few years later under the name MULTIBEAM LED headlamps. The LED-based adaptive main beam system enables the driver to leave the main beams switched on constantly. As soon as the system detects oncoming traffic with the help of a camera, it automatically adjusts the light distribution accordingly. The MULTIBEAM LED headlamps use a very fast responding and high performing precision LED module as a matrix light source, which features 84 individual, high-performance LED moduls. Each of these LED chips can be actuated electronically and independently, depending on the information supplied by a camera on the windscreen.

PRE-SAFE® Impulse Side uses a 360-degree sensor system, which permanently senses the car surroundings, to anticipate an unavoidable collision. When an unavoidable side collision with another vehicle is detected, the pre-impacting restraint system PRE-SAFE® Impulse Side transfers a defined energy to the occupant, thus sets him in motion towards the middle of the car already before the collision occurs [3]. Using numerical simulation as well as sled and vehicle testing, certain relevant occupant loads have been shown to be reduced by up to 30 percent on average with the use of PRE-SAFE® Impulse Side [4].



**Fig.10: The ESF 2009 and its “guarding angels”**

Another important mission of the ESF 2009 was to communicate about safety. That is the reason why the car also presented most of the modern safety systems that were already available in series production cars at that time. The ESF aim’s also at showing all the expertise of the safety engineers to the customers so that they can understand how Mercedes-Benz cars are reaching their high safety level. In order to explain the technical features of the car in a comprehensive way, the “guarding angels” communication concept was achieved. Beginning with the 2009 International Motor Show in Frankfurt (IAA), the car had been shown to the public all over the world during many years.

Even if the ESF 2009 still remains to some extends very forward-thinking, the on-coming changes in the society and in the way future cars will be used raised new questions for the automotive industry and for the safety domain in particular.

**PURPOSE OF THE ESF 2019**

The automotive industry will face major challenges over the coming years. The way coming vehicles will be used in the future will change dramatically compared to the way they have been used for the past 100 years.

This time, the occasion was the realization that the technical development and the expectations of automated driving change the requirements for safety technology in the car. Just like the first wave of ESV-vehicles was a reaction to mass motorization in the 1960s and its rising accident numbers, the new ESF reflects the mobility of the future and shows new approaches related to automated driving. At the same time, an ESF is always a technological figurehead for research and development in terms of safety. Not only does the ESF 2019 present innovations in Mercedes-Benz safety technology that go far into the future, but also it shows developments that are currently being prepared for introduction to series production.

What are the requirements for a safety system for an autonomous vehicle that operates in mixed traffic with changing infrastructure and differently equipped other road users? For a safety system that rides sometimes automated and sometimes controlled by the driver? Which of the classic passive security systems remain indispensable or need to be adapted? What additional new possibilities for avoiding accidents and reducing the consequences of accidents can be found in the technology developed in connection with autonomous driving?

Thus, the ESF 2019 is in some aspects a preview of what is coming, in others a vision, in others a contribution to the discussion and a tool to work on further improvements in road safety in the great tradition of Mercedes-Benz.

## CONCLUSION

The ESF 2019 successfully ties in with the long-standing tradition of Experimental Safety Vehicles from Mercedes-Benz. Like its predecessors, it shows trailblazing innovations to further improve future vehicle safety.

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