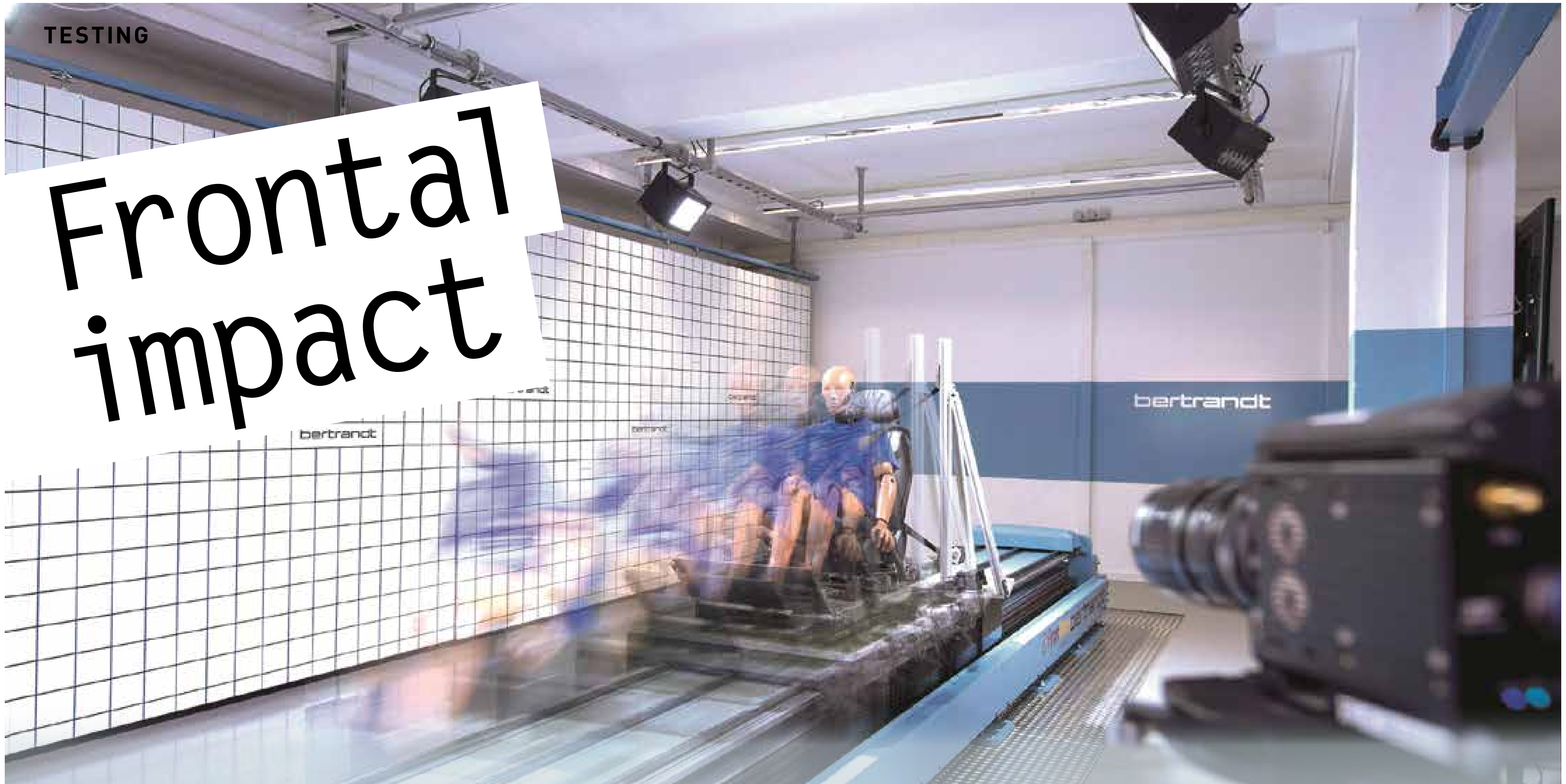
Frontal impact



A well-designed restraint system plays a key role in providing more effective protection for vehicle occupants, especially in frontal collisions. Test engineers at Bertrandt in Ingolstadt, Germany, are helping to improve these systems, with the emphasis on future requirements

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The function of a restraint system during a collision is to reduce the forces exerted on car occupants and therefore lower the risk of injury. In terms of their function, restraint systems are divided into primary and secondary components. Primary components – which include safety belts with pre-tensioners, fasteners and load limiters, together with frontal and knee airbags – reduce injuries. Secondary components – which include the steering wheel, steering column, instrument panel and vehicle body – fulfill other functions, but also have an effect on the restraint system.

Development of a restraint system typically takes three to four years. Stages include preliminary design, concept creation, prototyping and volume production. At the end of each stage, a certain level of quality must have been reached and tests must be carried out to confirm this (iteration loops), before the next stage can begin.

Close cooperation between simulation and testing teams brings major benefits for the design of restraint systems, including helping to ensure that tests are of high quality and keeping costs to a minimum. Using only physical testing for hardware would be very costly. For example, the robustness validation stage would require many configurations of component tolerances to be tested. Simulation models are also available earlier in the process than the components themselves.

During the initial phase, an analysis is carried out of the legal and consumer protection requirements in planned markets. The car can be positioned on the market on the basis of the required consumer protection objectives. A competitive analysis of these objectives in relation to safety equipment will give an indication of the parts to be used. Possible assessment criteria include biomechanical stresses on vehicle occupants, vehicle deceleration and active components of the restraint system. The preliminary selection process is completed by evaluating the previous car model.

The central components of a restraint system are the safety belt and airbags. Airbags were introduced in 1980 and have developed constantly. Components have to be compact, offer long-term stability and allow for a cost-effective manufacturing process. Newer challenges include larger volumes, the need to ensure reproducible behavior during inflation, and asymmetrical designs. The developmental focus is on an accurate and comprehensive analysis of all the parameters and influencing factors.

Bertrandt offers specialist airbag testing services in Munich, Mönsheim, Ingolstadt, Cologne and Tappenbeck, Germany. The company uses a variety of systems to apply a consistent load to the airbag as it is inflating, under highly reproducible conditions. These tests reveal information about the behavior of the airbag under maximum load and the failure of the airbag cushion. This allows application limits to be assessed accurately.

Because of increasing requirements relating to the mix of load cases that restraint systems have to withstand, airbags with a larger volume and an asymmetric shape will be fitted more frequently in future. This makes it more important to use optical analysis processes to assess the quality of airbags when they are folded and installed. The parameters that influence the manufacturing process are included in the evaluation. As a result, it is possible to identify whether and to what extent variations in production affect functional goals. Another consideration is the targeted aging of modules. Recent experiences on the market have indicated an increased need for simulation of the conditions that vehicles experience throughout the world and for rapid evaluation of different aging conditions, so the effects on the airbag's functionality can be understood. The focus is always on ensuring that the airbag fulfills its safety function throughout the vehicle's lifetime.

Concept to production

During the concept phase, suppliers develop components and test them on a substitute test bench similar to a real car. This should provide a definition of the components' basic performance and a selection of pre-validated simulation models. The simulation of this phase is also recommended.

Once the component development stage is complete, the full restraint system is evaluated for the first time, using sled tests and simulation. The challenging aspect of this is identifying the deceleration pulse, as no real structural pulses are available during the early part of the project. The sled tests ensure that the restraint system is well prepared for the subsequent vehicle crash test and crash simulation.

Ideally, the vehicle crash test should be the one-off final test in this stage of development. However, the restraint system often has to be evaluated more than once in these crash tests, because the structural pulses can change during the development process. The crash tests also allow detailed adjustments to be made to the restraint system. ‹

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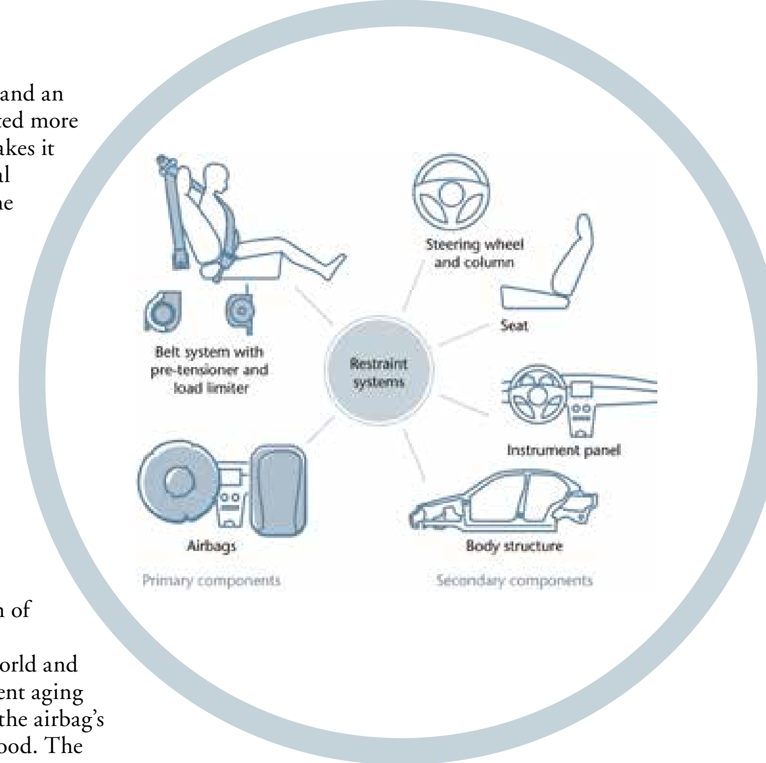

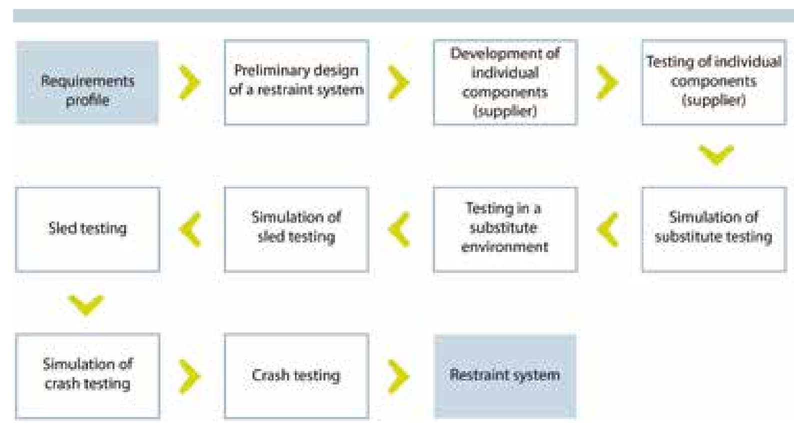

[Left] Sled testing at one of Bertrandt's sites in Germany

[Above] The components of a frontal restraint system

[Below] The development process for a car's frontal restraint system