”Rolling Chassis”: a concept co-developed by BENTELER and Bosch

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Modular and scalable system integration for electric vehicles: BENTELER and Bosch continue to develop their e-mobility platform

Electric vehicles, self-driving cars, internet connectivity. These are just some of the major trends and mobility concepts that are having a drastic effect on modern vehicle design. They require changes, not only to the way vehicles and their systems are built and interact, but also to the way the industry works. As a result, new systems and methodologies are needed. Two of the world’s leading suppliers to the automotive industry, BENTELER and Bosch, are combining their expertise to develop these systems and methodologies.

New challenges call for innovative thinking

Megatrends, such as reducing emissions and sustainability are having a significant impact on the automotive industry. New mobility requirements and trends are also playing a role. As a result, electrification of vehicles is continuously increasing. This is especially so in China, where the market for electric vehicles is increasing more strongly than in other parts of the world.

Battery electric vehicles (BEVs) present new challenges that are causing a paradigm shift in automotive design. The integration of an electric powertrain together with high voltage batteries located underneath the passenger compartment requires new approaches to vehicle architecture and safety. Brake systems, for instance, can assist steering behavior while the electric drive system is able to interact with and support braking functions.

To meet these new demands, BENTELER, together with its development partner Bosch, has developed a rolling chassis for battery electric vehicles (BEVs). The modular platform includes the high-voltage battery storage and thermal system, electric powertrain and chassis system with integrated steering and braking systems as well as control electronics. Customers benefit from a versatile e-mobility solution that can be tailored to their precise vehicle development needs.

From top hats to underbodies

The rolling chassis from BENTELER and Bosch provides an ideal starting point for application development. The underbody is the backbone of the platform to which most other systems are connected. It offers modularity in the areas of crash management, battery pack, integrated axle modules, E/E (electrical/electronic) architecture, safety and security. The platform is optimized for efficiency and performance and has already proven its capabilities in operation.

The upper body, or ‘top hat’ is not part of the development cooperation, but BENTELER and Bosch are able to specify the interfaces to the visible body shell designed in accordance with the vehicle type and the manufacturer’s desired styling. This is mated to the underbody. The top

hat is developed to meet the vehicle manufacturer's individual requirements, whether it's an SUV, family van or luxury sports car. As such, manufacturers enjoy complete freedom of design and styling while reducing development effort and speeding up time-to-market. The customer is thus provided with an optimum solution regardless of the segment and requirements.

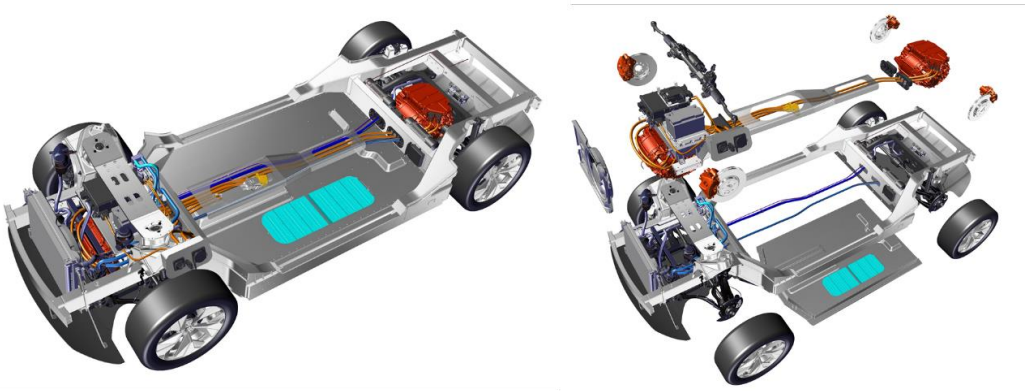
The challenge for established car builders
In addition to new vehicle types, new market models such as shared economy are emerging. In this new paradigm, cross-domain functionality is called for. The organizational structure of automotive companies is typically aligned vertically along the classical vehicle domains. This leads to greater complexity making cross-domain functions harder to implement.

To limit these system complexities and minimize risk, established manufacturers are increasingly demanding system solutions from suppliers. Rather than tendering for individual components, kit solutions are sought.

New players, new opportunities
New companies are also entering the automotive market with innovative business models. These manufacturers are looking for complete system solutions with high levels of integration that they can use as a basis for their own mobility solutions. In addition, there is an increasing need for shorter time to market.

The rolling chassis from BENTELER and Bosch with its defined and tested interfaces offers manufacturers a cost-effective solution to these problems.

One platform, countless possibilities



The rolling chassis developed by BENTELER and Bosch provides manufacturers with a modular, scalable platform as a basis for development of battery electric vehicles.

The rolling chassis developed by BENTELER and Bosch offers manufacturers a system integration platform that can be used as the basis of any battery electric vehicle. The chassis system includes the steering and braking system, battery storage with optimized thermal system, powertrain and power and control electronics.

To ensure that the rolling chassis addresses the broadest possible market requirements, maximum reusability and scalability were design prerequisites. In addition to linking existing elements, the partners developed completely new systems and components. By combining their

expertise, the two companies maximized their synergies in the integration of components and sub-systems. The result is pre-validated and partially validated assemblies that enable development cycles to be significantly shortened. This decisive advantage makes the rolling chassis an ideal platform for application development. Manufacturers can use it to develop a range of derivatives while benefitting from economies of scale and a shorter time to market.

The introduction of innovative functions such as interventions in the braking system to improve steering behavior rely on seamless interaction between domains. Cross-domain functionality, including the interaction between electronic and mechanical systems, is therefore increasingly important. In addition to these interactions, other drivers such as safety and security increase system complexity. Comprehensive cross-domain system development is called for.

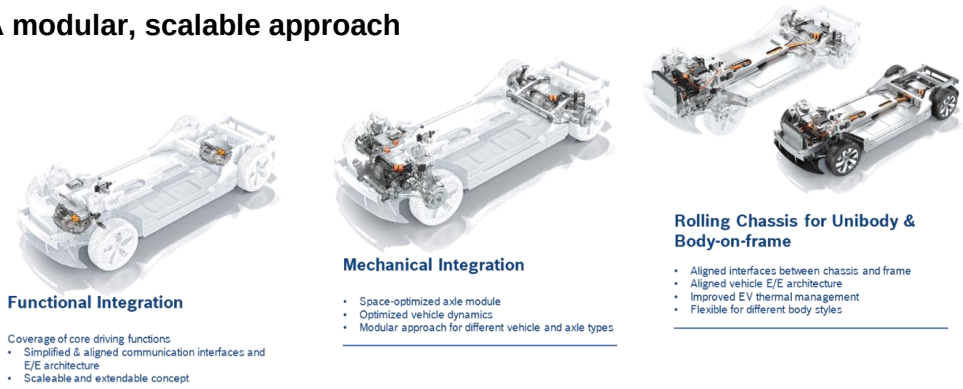
To ensure that its mechatronic components work together seamlessly in BEVs, Bosch has simplified interfaces and optimized the communication between components. This functional integration of the electronic modules and the software modules forms the basis of a ready-to-run rolling chassis.

The rolling chassis represents the highest level of integration and is ready for implementation by the customer. All components and subsystems from BENTELER and Bosch interact with each other using an optimal E/E architecture and sophisticated thermal management. The interfaces of chassis and frame fit together, on top of which the customer can design appropriate vehicle body-variants.

Overcoming system complexities
When new vehicles or classes of vehicle are being designed, functional requirements are defined based on the intended use, the design concept and the legal framework. These requirements form the basis of the development goals and are broken down to the subsystems and components. The relationships between these goals, however, often show a contrary dependency and the best possible overall system rarely consists of the ideal solutions of the subsystems. In the final analysis, the function of the complete vehicle becomes the overall benchmark.

This is the basis of the pre-integrated development platform realized by the cooperation between BENTELER and Bosch. It provides customers with a modular and scalable platform concept optimized for production. With development methods and processes from systems engineering, the development ensures the best possible compromise between the subsystems.

A modular, scalable approach



The rolling chassis combines functional and mechanical integration for both unibody and body-on-frame construction methodologies.

The concept uses a modular and scalable approach. Sub-systems can be combined flexibly according to the customer's specific needs and requirements. To meet the challenges that this presents, the design goal was to increase cross-domain knowledge and establish engineering competency on the vehicle level. This begins with scoping, use cases and stakeholder analyses at the vehicle level. Systems engineering identifies new features and derives system requirements, system architectures and finally component requirements. This frontloading approach helps to achieve an optimal fit between the subsystems and components and minimizes integration effort.

Underbody: The vehicle backbone
With the battery located under the passenger compartment, the design of BEVs differs significantly from other drive systems. The rolling chassis developed by BENTELER and Bosch forms the underbody. This is the backbone of the platform to which most systems are connected.

Depending on segment and vehicle class, several variants are possible. These include a scalable aluminum frame structure. For vehicles with higher volumes a cost-effective solution with a steel underbody as used with self-supporting bodies can be selected. With both of these, the longitudinal and transverse dimensions can be tailored without changing the basic structure of the connected systems. This allows the platform to cover a wide range of different vehicle segments and, where required, allows different top hats to be implemented on a single platform. As with conventional body concepts, the underbody is divided into front, middle and rear sections. This scalability at the vehicle level means that, for example, the rear section can be adapted to special requirements, such as a larger trunk.

The conventional core functions of a vehicle body, such as crash safety, played a central role in the design of the rolling chassis. The requirements for e-vehicles are particularly interesting in the passenger cell area, where the differences compared with combustion engine vehicles are most clearly seen. With the high-voltage battery located underneath, a new approach is required, for example in the case of a side impact. In the event of a side impact, for example, power must be isolated and potentially hazardous battery fluids safely contained. New functional interactions are also needed. Ensuring that the body and battery will interact in a way that ensures maximum safety calls for detailed knowledge of both areas. BENTELER has extensive experience in building structural components for conventional vehicles. With the rolling chassis, the company has applied its expertise in protecting passengers to shielding the high voltage batteries from damage.

The result is a sophisticated body concept that supports a wide range of systems, from the battery pack and integrated axles to thermal management and the electric/electronic (E/E) architecture.

Battery cooling
The battery cooling system is designed for a 100kW quick charge of the battery pack. 3D CFD simulations carried out early in the development phase showed that separately fed U-shaped cooling channels would deliver the best results. Short flow paths in each section limit the heating of the cooling medium ensuring a homogenous temperature profile.

Integrated front and rear axle modules
The modular approach used for the chassis system includes an electrically driven front and rear axle module, which combines excellent performance with efficient design. The axle systems are scaled in accordance with the required vehicle properties and dimensions. In addition to

different height levels for limousines and SUVs, adjustments to the track widths and a differentiation of the different load groups are also possible.

The front axle is based on a dissolved double wishbone suspension axle geometry.
A 5-link axle was chosen for the rear axle as this creates the ideal conditions for combining an optimized topology with the lowest costs and weight. A driven McPherson axle is used as the front axle for the B/C segment with a twist-beam axle at the rear. The connection points for the different axle systems are identical in each case, allowing the highest possible common part strategy to be realized

Stabilizers can be designed as passive or active elements, as can the dampers. Rear axle steering can also be integrated as an option to improve performance and parking behavior. Steel or air body springs can be integrated on the front and rear axles.

Different driving dynamics for particular segments can be achieved through elastokinematic optimization of the rubber chassis mounts. This means that the same chassis components can be used for different segments producing further economies of scale.

All these aspects combine to make a flexible chassis system that can be readily adapted to customer requirements. The result is a significant reduction in development time, faster prototyping and competitive time-to-market offering.

The heart of the matter: mechatronics from Bosch

From the vehicle control unit to the thermal management system and E/E architecture, Bosch brings its expertise to the rolling chassis in a range of mechatronic subsystems. These are designed, implemented and integrated in close cooperation with BENTELER and other development partners.

Vehicle Control Unit (VCU)
The Bosch Vehicle Control Unit (VCU) is the central control unit of the rolling chassis. It performs functions such as longitudinal control, operating strategy, high-voltage coordination, charge control, on-board diagnosis, monitoring, thermal management, terminal concept and much more.

For highly automated driving, the VCU can also cover fail-operational functions for safe vehicle operation in an emergency. Besides these drive-related functions, cross-domain functions such as predictive and automated longitudinal guidance, Advanced Driver Assistance System (ADAS) connection as well as functions of body controller are increasingly supported in higher-level versions.

Thanks to its modular and configurable hardware and software, the VCU can be flexibly adapted to future requirements.

eAxle
Two Bosch eAxles with 150 kW each on the front and rear axles are integrated in the rolling chassis. The modular design and flexible manufacturing concept of the eAxle allow customized solutions to be implemented in terms of performance data, torque and installation space.

The eAxle’s power output can be scaled from 50 to 300 kilowatts, enabling it to be installed in small cars, SUVs and even light commercial vehicles. Continuous optimization of the motor and

power electronics together with a reduction in the number of interfaces and components give it a high degree of efficiency. The optimization and combination of these individual parts leads to a significant gain in efficiency, especially in connection with modern thermal management.

Integrated Power Brake
The integrated power brake is a pure electro-hydraulic solution that combines brake force boosting and ESP functionality in a single unit. It offers high dynamics and helps to make the rolling chassis even more efficient through electrically controlled brake inputs. The integrated design of the brake system eliminates the need for classic components such as a vacuum pump or vacuum brake booster.

Electric Power Steering
The electromechanical power steering system controls and assists vehicle steering with the aid of an intelligently controlled electric motor. Based on the steering signal from the torque sensor, the electronic control unit calculates the optimal steering assistance and sends this information to the electric motor, which then provides the force needed.

Bosch has developed an intelligent steering concept that incorporates both the electronic control unit and innovative software that links other vehicle systems and components. The electric power steering thereby becomes the key technology for automated driving.

Thermal management
The correct design of thermal management is becoming increasingly important for eMobility as well as regulating heat flows inside the vehicle to ensure a comfortable environment for passengers, it also maintains components at their respective optimum temperature range. With the thermal system used in the rolling chassis, BENTELER is responsible for battery cooling and Bosch is responsible for system design, software and components for controlling the cooling system.

E/E Architecture
E/E architecture in vehicles is currently undergoing a paradigm shift. Automated driving and connected services are leading to significant functional growth within the E/E architecture. To control this complexity reliably, centralized, cross-domain architectures are employed. Here, many individual ECUs are partially replaced by a few but very powerful vehicle computers. The high demand for flexibility and scalability are important drivers for this change. This reduces costs while the shortened performance paths and optimal integration result in a considerable weight reduction.

The use of VCUs in the rolling chassis allows the introduction of new cross-domain functionalities and saves resources in the subordinate control units. A complete low-voltage communication cable harness together with the high-voltage cable harness including connectors and a separate power distribution unit have been specially developed for the system. The VCU takes over the complete control of the thermal system.

Putting theory into practice
The system integration platform created in the development cooperation by BENTELER and Bosch offers both established OEMs and start-ups far-reaching advantages. Thanks to a network of partners and suppliers, OEMs benefit from faster industrialization and lower investment in production facilities. Plus, vehicle manufacturers can shorten their development times and achieve faster market launches. And it’s already gaining traction, enabling new players to enter the market and disrupt it in completely new ways. In 2019, for example, the

Evergrande Group announced its intention to enter the electric vehicle market using the platform as the basis of its electric vehicle chassis architecture. An exciting demonstration of the opportunities and potential the platform offers.