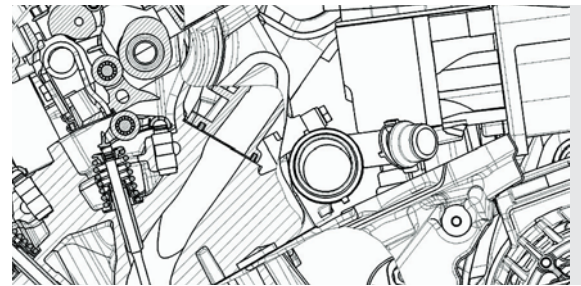


Research and Development

Specialists within BMW Group's Research and Development use the most advanced methods and technologies in systematically converting new concepts and ideas into genuine innovations in the automobile. Because only innovations will enable a car maker to stand out clearly from the competition in future.





The automotive industry operates in an area characterised, on the one hand, by growing customer demands and complex requirements within society and, on the other hand, by development times constantly becoming shorter and economical, corporate impacts becoming greater. The real challenge and art in automobile development, therefore, is to convert these many, in some cases contradictory, objectives and requirements into an all-round, truly convincing product.

The technical "brain" of the BMW Group, today's Research & Innovation Centre referred to for short as the "FIZ", was established in the north of Munich in the mid-80s in order to efficiently link the search for new solutions with the development and implementation of products ready for production. Providing short distances and keeping employees close together, the FIZ Centre promotes the cooperation of more than 8,500 specialists in all areas and disciplines. Engineers, designers, model builders, computer specialists, scientists, production specialists as well as purchasing managers and employees from suppliers work together here on the car of the future.

The process: from the first idea to the finished product

Three questions are of fundamental significance at the FIZ Centre: What does the customer want? How quickly is a vehicle developed? How quickly will it be built and delivered to the customer?

Whilst the Customer-Oriented Sales and Production Process provides the answer to the last question*, the BMW Group has established the Product Evolution Process or PEP in order to optimise the actual process of developing a new vehicle. This is the process which every BMW and MINI follows in development from the initial idea all the way to full-scale series production. The PEP concept differs from the former process of developing a new car just about the same way a computer differs from a slide-rule: Instead of working in one step after the other, as many individual tasks as possible are handled simultaneously and compiled in a multi-level, exactly defined plan providing the final result. Cooperation is therefore based not on isolated responsibilities, but rather on joint project management (simultaneous engineering).

Like computer technology, the PEP process is constantly evolving: What 16, 32 or 64-bit technology means in the virtual world, is comparable in this case with the parallel development of an increasing number of functions and new vehicle generations in shorter intervals.

Masterminding individual vehicle projects

Since mid-2000 the company has grouped vehicle projects similar to one another in technical terms within so-called product lines under the same responsibility. Each product line covers 1-2 vehicle segments, MINI and its variants, for example, being developed in one product line. Operations within the product lines are closely linked to one another in order to capitalise on joint resources and develop product features in one and the same process. This saves both time and money and allows the rapid introduction of new technologies on a broad scale.

The idea is to use common values and resources while maintaining the greatest distinctions wherever necessary. So that each customer will continue to receive his personalised, individual car.

ConnectedDrive networks the driver, the car and the surroundings*

Communication and information technology give the automotive industry new opportunities for intelligent mobility in the future. BMW ConnectedDrive, for example, is a system networking the interaction of the driver, the car and the surroundings.

Two examples already being examined in a test car are the use of ConnectedDrive in stop-and-go traffic, helping the driver in the constant process of applying the brakes and accelerating again, and the contribution to safety made by ConnectedDrive on winding country roads – particularly at night –, with the gas pedal "telling" the driver to slow down by exerting greater counter-pressure against the driver's foot.

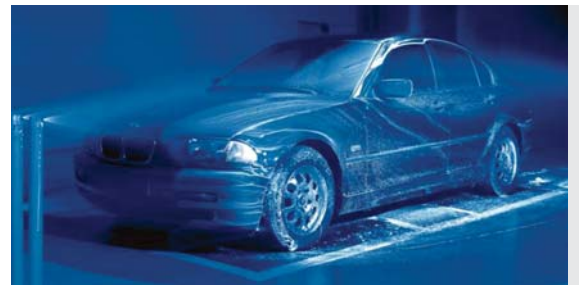
These examples show that ConnectedDrive takes a new approach: It combines and supplements telematics, online services and driver assistance systems so far operating individually, giving the driver specific, to-the-point information. So you might say that ConnectedDrive is a kind of virtual co-driver offering the driver the right information the right way and at the right time.

The BMW Group sees ConnectedDrive as a service offered to the driver. It is important, however, not to take away the driver's responsibility, but rather to give him support in his decisions.

* See the Current Factbook on ConnectedDrive for more details.

* See the Current Factbook on the BMW Group's Production and Development Network for more details.





Focusing on innovation

With competition becoming fiercer all the time, it is absolutely essential to stand out from one's competitors. And here innovation is a crucial factor.

The BMW Group focuses its development and job structures consistently on the need for innovation. All activities throughout research and advanced development, for example, are oriented towards so-called strategic innovation areas – sectors in which the company seeks to achieve leadership in technology. Interdisciplinary, interdivisional decision-making groups ensure optimum support and follow-up of innovations from the initial idea all the way to its actual implementation in vehicle concepts of the future.

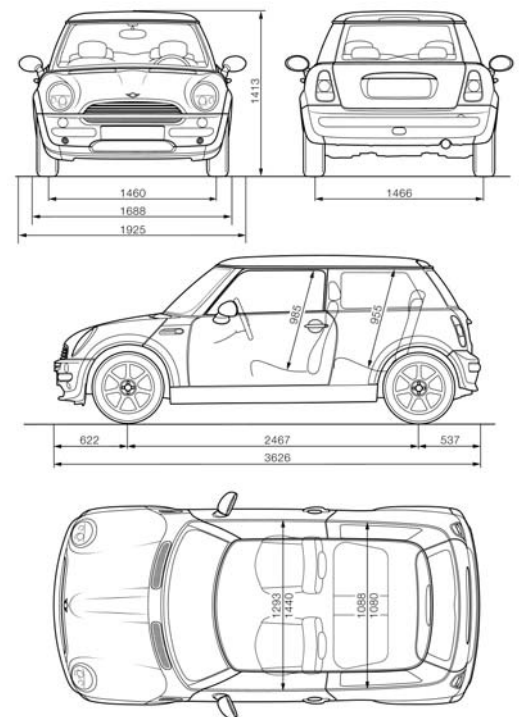
Not every new idea in automotive production is however a genuine innovation in the eyes of the BMW Group: Rather, the company acknowledges only products or components offering the customer significant additional benefits as real innovations.

Symbolically, the re-orientation of research and development is characterised by the new name of the FIZ Centre, formerly referred to as the Research and Engineering Centre and now, as of the year 2001, more appropriately called the Research and Innovation Centre.

Innovations driven by electrics and electronics

Electrics and electronics are now the main driving force behind about 90 per cent of all BMW Group innovations. The Group's objective in this context goes far beyond the combination of mechanical components and electronic control systems, that is so-called mechatronics. For the car of the future

will be an integral component within a broad network of information, messages, transactions and services. Information will be available in the car like at any other place. Mobile shopping, mobile banking or information on demand will be standard processes. The electronics revolution will open up options for additional services and business areas, for example the option to market software accompanying the vehicle.



x-by-wire: electronics replacing mechanical systems

Concepts such as ConnectedDrive will make motoring safer and more convenient in the future. One of the prerequisites is x-by-wire technology, with electrical cables and electronic units making mechanical or hydraulic systems redundant. The "x" in x-by-wire will then be replaced in each case by a specific name or term, such as brake-by-wire, steer-by-wire, or shift-by-wire.

In the BMW 7 Series shift-by-wire replaces the mechanical connection between the selector lever and the six-speed automatic transmission. Instead of using the selector lever in the centre console, the driver chooses all gearshift programs or gears directly on the steering wheel.

The Z22 experimental car already goes far beyond this development. Both the steering and the brakes are applied electronically, without any kind of mechanical systems. And whilst the driver still masterminds the basic functions from the steering wheel and brake pedal, the systems can do a lot more: Struggling hard to turn the steering wheel, for example when parking, is now a thing of the past, a maximum steering wheel angle of 160° ensuring that such manoeuvres can be performed with minimum effort. Although this operation of the steering is still a bit unusual at the beginning, since the driver will "automatically" try to turn the steering further than it will go, he will very quickly benefit from the superior comfort this system has to offer.





Virtual tools are indispensable

To reduce the cost and time of development, computer-based systems have become an indispensable tool at the FIZ Centre.

Today all production cars within the BMW Group are first presented, tested and optimised in virtual reality before being shaped "in the metal". All parts and components of a car are first rendered digitally and can be assembled virtually within seconds long before the first prototype sets out on its maiden trip on the test track.

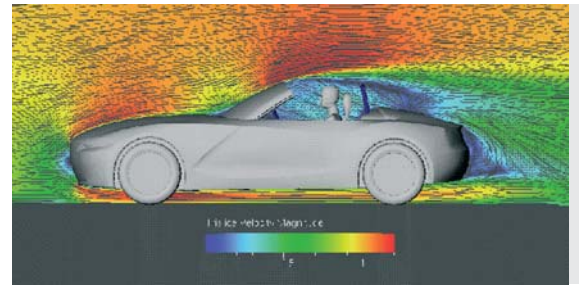
Using specific virtual methods, the specialist can clearly visualise physical properties such as vibrations and acoustics or aerodynamic qualities as well as thermal behaviour, which normally are invisible. The "weather maps" compiled in this way provide the basis for a wide range of further calculations and examinations before the results calculated on the virtual model can be verified and further refined on the actual hardware, that is on components or the first real prototype.

It is essential when taking this approach to have all relevant information available simultaneously in a kind of network: In vehicle projects all major product, process and project data, regularly updated to the latest status, is available at all times to each BMW associate over the Intranet. This significantly facilitates and expedites the simultaneous interaction of designers, engineers, purchasers and suppliers working on one project.

Networking the BMW Group's think tanks

To properly observe and monitor trends and customer requirements, BMW Group research and development operating worldwide must also focus locally on the various sales markets. This is why the BMW Group has two Technology Offices in Palo Alto/California and in Tokyo as well as BMW Technik GmbH in Munich. Two other BMW locations in California are Designworks/USA and the BMW Engineering and Emissions Control Test Center.

Specifically the Palo Alto Tech Office seeks to detect and unveil new trends and ideas. Right in the middle of Silicon Valley BMW has a small team of information scientists, experts in logistics, and engineers in many different disciplines working on the introduction of the latest technologies at the earliest possible point. Clearly, BMW's development specialists benefit in this process from the electronics and software companies in the Valley.



The BMW Group also does pioneering work in Germany and Austria:

- New methods for the production of plastics and light-alloys are developed and tested at the Landshut Innovation and Technology Centre.
- The BMW Group develops all its diesel engines at the Group's largest engine plant in Steyr/Austria.
- Experts in informatics at BMW Car IT in Munich work on software solutions for the car of the future, without having to consider the usual corporate processes.
- The Development Centre of BMW Motorcycles is directly adjacent to the FIZ Centre. This is where innovations such as integral ABS and the safety concept of the BMW C1 first saw the light of day.

Intelligent lightweight engineering saves fuel

One of the greatest tasks facing the engineer in automobile development is to save fuel. But optimising the drivetrain alone is not sufficient to reach this goal. "Lightweight engineering" is therefore one of the key terms in automobile development.

The BMW Group believes that the best way to achieve the necessary results is through an intelligent mix of materials. An example is the first aluminium chassis in the BMW 5 Series (1995) then developed to an even higher standard in the BMW 7 Series, proving that the company uses lightweight materials wherever it makes sense. Which in this case is to optimise axle load distribution and driving qualities.

Apart from aluminium, magnesium and fibre-reinforced materials will also gain greater significance in automobile production in the future. Which material is used at the end of the day depends ultimately on the specific qualities of the materials, the availability of suitable joining methods, recyclability, and economic factors.



Innovative automobile development - from the original vision to success in the market

Standard development phase

Preliminary phase



Product

- Implementation in project teams**
- Design
 - Testing
 - Quality
 - Costs
 - Production planning
 - Purchasing/logistics
 - ...



Project teams

Assessment, decision

Advanced development

Innovations

Ideas

Targets

Orientation / Focus / Analysis

Feedback

Vision



VISION

Demands

- Customer requirements
- Safety
- Fuel consumption
- Emissions
- Recycling of raw materials
- Legal requirements
- ...





The FIZ Centre and Formula 1 – a winning team

One of the main reasons for the BMW Group's re-entry into Formula 1 in the year 2000 was the transfer of knowledge from motorsport to series development. This is why BMW's Formula 1 engine plant is just a stone's throw away from the Research and Innovation Centre.

The know-how of the FIZ engineers makes a significant contribution in ensuring the strong position of the BMW WilliamsF1 Team. Whether it is the cylinder head, the crankcase or the electronic control system – all main components of the V10 power unit were developed by BMW in-house. And the same applies to the production of the Formula 1 engine, the foundry for core parts of the 850 bhp power unit being based in Landslut right next door to the casting shop for series production engines.

Ultimately the customer also benefits from this close cooperation, know-how gained in F1 enhancing the Group's own knowledge and going straight into series production. Among the many examples there is the engine management system developed by the same team in Formula 1 also responsible for the electronics in the M3 and M5.

Human resources in research and development

The biggest asset the BMW Group has for the future is however not our electronic systems or our buildings. It is the people who work for the Group, their skills, their commitment and enthusiasm. They are the heart of research and development.

The BMW Group regularly ranks among the most popular employers in Germany. In enquiries conducted within the Development Division the associates always show their enthusiasm: Apart from the "thrilling product", they are motivated in particular, in their own words, by ongoing personal and professional challenges, by the opportunity to shape the future and the high standard of freedom and flexibility the FIZ Centre has to offer.

To make sure things stay this way a clear focus on the associates is one of the BMW Group's primary objectives. And sometimes it is even the small things – such as the BMW Group's shopping and ironing service – that contribute to the pleasure of working in research and development.



BMW CleanEnergy: the age of hydrogen has begun*

Jules Verne made the point quite clear in 1874: "Water is coal of the future". For only hydrogen recovered from water by using electrolysis meets all the demands made of the ideal fuel in the years and decades to come. Additionally, if recovered by means of renewable energy, hydrogen is the cleanest fuel imaginable.

With its sixth generation of hydrogen cars, the BMW Group has already come very close to this vision. Following the BMW 750hL, the first hydrogen car in the world built in a small production volume, the Group presented the BMW 745h prototype at the 2001 Frankfurt Motor Show, based on the current 7 Series and equipped with a petrol-/hydrogen-powered 8-cylinder. The car can be run on either hydrogen or conventional petrol.

BMW believes that the customer should continue to benefit from the dynamic performance and agility provided by a conventional engine but also have the option of switching to the highly environmentally friendly use of hydrogen.

The BMW Group is also working on the ongoing development of the fuel cell. It will serve in future primarily to power the on-board network and giving the customer additional functions such as auxiliary air conditioning and by-wire technologies.

* See the Current Factbook on Hydrogen Drive for more details.



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