

# Research and Development Network. From the Original Idea to Final Innovation in a Networked World.



Innovation is the driving force for the success of the BMW Group. Innovation coming from a global Research and Innovation Network where the BMW Group's development specialists work close together and develop solutions today for mobility challenges of tomorrow. Visions, creativity and passion thus serve to create products offering the customer the direct benefits and experience of the BMW Group's innovative power.

**BMW Group**





## The Driving Force: Passion for Innovation.

The image of the ingenious inventor working all by himself in his workshop has long been a thing of the past in the automotive industry. Today some 8,900 specialists interact with one another in the BMW Group's Research and Development Network. Through efficient processes and close interaction of the development departments, each individual contributes directly to the creation of new products and, as a result, to the overall success of the BMW Group with its brands BMW, MINI, and Rolls-Royce.

The innovative power of the BMW Group is confirmed by approximately 60,000 design utilities and protective rights – thereof some 13,000 patents –

already in place and almost 900 new or extended patents made out in the year 2008 alone. But not every good idea is necessarily a genuine innovation. Only ideas offering the customers added value and benefits they will really feel, are pursued and examined in greater detail. Quite simply because “innovation” is not a purpose in itself for the BMW Group, but rather a specific line of action oriented towards the customer. Precisely this is why the BMW Group concentrates on clearly defined areas of technology from which the customer benefits directly and promotes in particular those developments which stand for ongoing progress in the areas of safety, economy, and driving pleasure.

## Active Innovation Management.

Keeping a close eye on customer benefits, the BMW Group pursues a three-stage process of innovation. First, the development specialists, interacting with partners in development from all over the world, identify trends and technologies pointing into the future. Taking the second step, specialists in innovation management assess the results achieved for their technical and economical implementation, as well as the benefits actually offered to the customer. Solutions developed in this way to the appropriate standard of technical maturity are then carried over by the BMW Group's engineers to the series development process and, ultimately, to a specific product.

### **The culture of innovation**

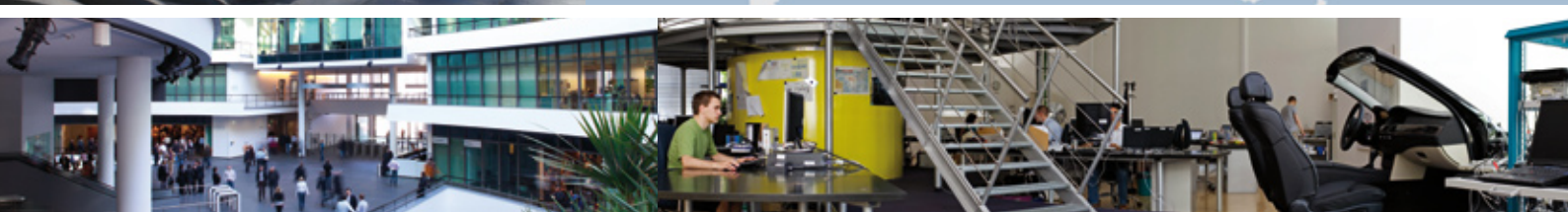
The future of the automobile is established by the BMW Group through a deeply rooted culture of innovation lived out every day in all areas of development. Together with suppliers, universities and research institutes, BMW examines and assesses future-oriented trends and technologies also in areas such as aerospace or the software industry,

considering how these technologies and developments might be transferred into the automobile. Working together in a constructive atmosphere, BMW Group specialists then continue the development of these ideas, upgrading them where appropriate in an efficient process all the way to regular production.

### **Architecture with short distances**

To ensure the rapid implementation of innovations, the BMW Group keeps communication routes as short and efficient as possible. This also comes out most clearly through the architecture of BMW's Research Centre: The Research and Innovation Centre in Munich allowing direct and short-distance communication of employees through its honeycomb structure dates back to the year 1986. The adjacent Project Building, again through its architecture, follows the so-called Product Creation Process of the BMW Group, bringing together all specialists from Development, Production and Purchasing in one joint project area while working on a specific vehicle project.





## The BMW Group's Research and Development Network – Eleven Centres in Five Countries.

To recognise trends in good time and offer appropriate, tailor-made solutions, it is essential for the BMW Group to communicate directly with the most important markets. Incorporating eleven locations in five countries, the BMW Group's Research network spans the entire world and is always up-to-date. Strong partnerships with, say, local universities and research institutes also ensure that the BMW Group Research Network is always technically up-to-date and clearly oriented towards the customer.

### Interaction of Development Centres

The technical heart of the BMW Group beats in the BMW Group Research and Innovation Centre or the "FIZ", as it is called for short. One of the most advanced development centres in the global automotive industry, this unique facility serves as the central interface for all technical and design-related activities in BMW research and development. All of the BMW Group's other Innovation Centres are directly connected to the FIZ, acting as both a service provider and driving force in the development process.

The two subsidiaries BMW Forschung und Technik GmbH and BMW Car IT GmbH are both based in Munich, working on new technologies for use in the automobile. At the same time the BMW Group's Research and Technology Division interacts closely with its own global network of partners in research and development.

The BMW Group's Diesel Competence Centre is BMW Motoren GmbH in Steyr, Austria. Cooperation with specialists in production and with suppliers starts here from the very beginning in the initial stage of development. The same applies to the Innovation and Technology Centre in the German town of Landshut, where in particular specialists on lightweight technologies examine and develop innovative materials and appropriate production methods. Thanks to the strategically favourable location of the Landshut Centre between Vehicle Development and Production, knowledge gained here goes straight into the construction and production of new components and vehicles.

BMW Group Research and Development is represented in the United States by no less than four institutions. The California Innovation Triangle comprises not only the BMW Group Technology Office in Palo Alto, but also the Engineering and Emission Test Center in Oxnard as well as BMW Designworks USA in Newbury Park. The US Development Office, in turn, is located on the East Coast in Woodcliff Lake.

The BMW Group has additional Development Offices in Beijing (China) and Tokyo (Japan).

2007				2008				2009				
9,800				9,300				8,900				Headcount Research and development network
3,144				2,864				2,488				Research and development expense in Euro million
5.6				5.4				4.8				Research and development ratio in %



## Efficient Dynamics – Even Better Performance on Even Less Fuel.

The BMW Group initiated the Efficient Dynamics development strategy quite some time ago in the year 2000 – and ever since this strategy has served to consistently innovate products in reducing both fuel consumption and CO<sub>2</sub> emissions while offering an even higher standard of performance and driving dynamics. A further important point is that the technologies introduced in this context are not limited to specific models, but rather develop their full impact as a firm and regular feature of the BMW Group's entire car fleet. As a result, BMW Group average fleet consumption has dropped faster and more consistently than that of any other car maker in recent years.

Efficient Dynamics consistently queries existing solutions throughout the entire car, searching steadily for new options in making mobility increasingly efficient in future and reducing the use of resources in the process. Apart from the ongoing enhancement of conventional drive systems and hybrid solutions in their efficiency, the Efficient Dynamics strategy includes alternative drive concepts such as electro-mobility or – in the long term – hydrogen gained in a regenerative process.

### Achievements so far

Reduction of CO <sub>2</sub> emissions by BMW Group cars the EU from 1995 – 2008 by almost		27 %
CO <sub>2</sub> emissions by BMW Group cars in Europe (EU15)	2005	189 g/km
	2008	154 g/km
Everyday use of hydrogen proved in BMW Hydrogen 7 over an overall distance of more than		4 mill km

### The future – BMW Vision EfficientDynamics

Overall output	262 kW/356 hp
Performance estimate	0 – 100 km/h in 4.8 sec
Fuel consumption in the EU test cycle	3.76 ltr/100 km (equal to 75.12 mpg imp)
CO <sub>2</sub> emissions	99 g/km
Drag coefficient (c <sub>x</sub> )	0.22

The BMW Vision EfficientDynamics concept car demonstrates the options possible in the context of Efficient Dynamics, clearly bearing out the objectives and potential of this development strategy in concentrated form: a combustion engine with supreme efficiency, intelligent energy management, BMW ActiveHybrid technology with innovative storage of electric power, intelligent lightweight construction and aerodynamics consistently optimised to the highest standard.

The ambitious aims of the BMW Group in pursuing Efficient Dynamics are also borne out by the establishment of the Aerodynamic Test Centre in 2009 and the Energy and Environmental Test Centre in 2010. The new wind tunnels and climate chambers created here open up new, realistic development options in areas such as aerodynamics and energy management highly relevant to the reduction of fuel consumption.

### Electro-mobility

Introducing the MINI E, the BMW Group already enables the motorist to drive with zero emissions today through an alternative powertrain. In a test fleet of no less than 600 cars, the MINI E, with its 150 kW/204 hp electric motor, provides a convincing example of sustainable mobility without foregoing the usual standard of driving pleasure. Hence, the MINI E, as MINI's first zero-emission car, already meets the most demanding challenges for mobility of the future.

Another fleet of BMW electric cars will be making its appearance on the road in 2011, both test fleets offering important findings for the series production of electrically driven cars before the end of this decade.





## Connected Drive – the Car Communicating with its Surroundings.

A further highlight in the process of development is networking the car with its surroundings and traffic conditions. An ongoing process of innovation dating back to the early 1970s has culminated in the introduction of BMW ConnectedDrive for greater comfort, enhanced infotainment, and superior safety in the car. Connected Drive ensures active exchange of information between the driver, the car and its surroundings, leaving lots of space for further, trendsetting innovations still to come.

Highlights of Connected Drive the way it is established today include BMW NightVision even able to detect individual persons, a telephone enquiry service transferring data straight to the navigation system, the option to download routes into the navigation system through mobile connections or USB, as well as an Enhanced Emergency Call function. A further essential point is that Connected Drive makes the BMW Group the world's first car manufacturer to allow unrestricted use of the internet in the car.

### Safety also after an accident has occurred. Faster rescue increases chances of survival.

Average rescue time for accidents outside of town (in Germany).

Time until the accident is noticed	Actual duration of report	Time required for planning and departure	
2.2	7.8	Time for reporting the accident	1
		1	9.2
		Driving and search time	
1.5	1	1	8.2
Rescue time shortened by an automatic emergency call			
minutes		11.7	21.2

### Road traffic statistics in Germany

1970	20.8 mill motor vehicles registered
2008	51.3 mill motor vehicles registered
1970	201 bill kilometres (125 bill miles) covered
2008	690 bill kilometres (429 bill miles) covered
2009	(Forecast: approx 687 bill km/427 bill m)
1970	21,332 traffic fatalities
2008	4,477 traffic fatalities
2009	(Forecast: approx 4,100 traffic fatalities)

### Enhanced Emergency Call

The most important requirement in an accident is to provide help quickly and fully in line with the requirements encountered. Precisely this is why the BMW Group has offered an emergency call function ever since 1997, the car itself alarming the BMW Call Center in the event of an accident and at the same time transmitting data crucial to the survival of the individuals involved. Apart from its exact location, the car also transmits data from numerous built-in sensors, giving rescuers, before they even arrive at the scene of the accident, detailed information on the type of collision as well as the number of occupants and their risk of injury. This life-preserving service is the product of close cooperation between BMW Group accident researchers and safety experts, on the one hand, and accident physicians at the William Lehman Injury Research Center in Miami, USA, on the other.

### MINI Connected

Connected Drive has been developed to a very special standard in MINI: MINI Connected. This particular system integrates an internet-based consumer electronics device such as a Smartphone into the MINI: With the Smartphone being able to access the internet, MINI Connected establishes a direct link with the world outside the car, the internet or social communities. This will enable the MINI to twitter in future, using vehicle data to send out a message such as "Driving in the direction of Palo Alto at a current speed of 56 mph".

### AMULETT

The AMULETT Research Project shows how pedestrian safety may be further improved in future by Connected Drive: AMULETT focuses on accidents which happen whenever the driver fails to see a pedestrian or sees him too late. To perform this function the vehicle communicates with a radio transponder on the pedestrian's body. Receiving an enquiry from the car, the transponder sends out a signal pinpointing the location of the pedestrian and identifying him as a road user at the risk of injury. This warns the driver and allows him to respond appropriately. Research is even being conducted on the option to apply the brakes automatically in an emergency.



### **BMW Motorrad ConnectedRide**

As a manufacturer of both cars and motorcycles, the BMW Group includes two-wheel vehicles in its research projects. With vehicle-to-vehicle communication offering significant safety potentials in future, the Intersection Assistant from BMW Motorrad ConnectedRide focuses on one of the main kinds of fatal motorcycle accidents: Car drivers often overlook motorcycle riders, whether out of negligence or because the driver's vision is concealed.

This assistance system tells the driver whenever necessary to wait at a road junction, etc, at an early point in the risk of an upcoming collision – sending out this warning as a visual, touch and acoustic message in separate steps. In the same process the safety system switches on and varies the intensity of the motorcycle's headlight and activates the LED warning lights on the side of the motorcycle to ensure better perception. In the case of an acute collision, BMW Motorrad ConnectedRide even activates the motorcycle's horn. The objective is to make the car driver aware of a potentially critical encounter and thus to ensure extra safety on the road.

## **The Emotional Driving Experience – the Sum Total of All Impressions.**

While we all enjoy Sheer Driving Pleasure in a different way, such pleasure is always the sum total of individual impressions while driving. Hence, everything we see, smell, hear and feel must fit together to provide one unique experience creating driving pleasure in the process. Precisely this is why the BMW Group gives great attention to each and every detail. Together, all the components of the vehicle, the sound of the engine, the design of the vehicle, as well as the interior with its features and configuration, create a highly emotional (driving) experience.

### **Driving dynamics**

Whether the car is a BMW 3 Series, an X5, a MINI or a Rolls-Royce – depending on the concept of the vehicle, the driver has very different expectations as to his driving experience. Hence, the chassis and suspension are designed and laid out appropriately for each car, bringing together sportiness, comfort and safety in the right character, whether at day or night, in rain or snow, in dense traffic or on an open country road.

Specialists at the BMW Group work hard to further enhance this range of features through electronically masterminded control systems such as Dynamic Stability Control (DSC) or Dynamic Performance

Control raising vehicle safety and response to an even higher standard and ensuring even greater driving pleasure in the process.

### **Driving with all your senses**

Driving dynamics also means hearing the right message and receiving the right auditive feedback, since apart from the straight-ahead and lateral acceleration the driver actually feels, it is particularly the acceleration he "hears", that is the sound of the engine, that contributes to the subjective driving experience. Sound design therefore opens up many options to support the character of the car and individualise the driving experience as such.

With this in mind, BMW Group researchers modify the sound within the car through a sophisticated electro-acoustic system. As a result, a four-cylinder might sound inside the car like a muscular straight-six or a large-capacity V8. Whether this serves to enhance the driver's personal fun factor through the specific sound of the engine or – more importantly – whether it serves to "reward" the driver acoustically for a more efficient style of motoring, is currently being examined in various research and pre-development projects.





## BMW Group Design – Passion for Aesthetics and Dynamics, Precision and Perfection.

### Taking an all-round approach

The process of product creation applied by the BMW Group creates vehicles with unmistakable and authentic character typical of the brand. Such character is borne out not least by the design of the car or motorcycle, with the careful match of the exterior and interior, as well as the materials and colours providing an appropriate all-round balance of harmony. Each surface, each line and each detail is appropriately designed to give the vehicle overall harmony throughout.

Exterior and interior design expresses the personality of the product through its strong design language. Each discipline must fulfil numerous requirements in this respect, with typical BMW features such as a long wheelbase or instruments clearly oriented to the driver, superior ergonomics and outstanding safety being only some of the highlights.

The customer experiences this powerful design in everyday use also through the surfaces of his vehicle. Material and colour designers then make the process of driving the car an even greater experience through the right combination of high-quality materials and exclusive colour compositions, bringing together the exterior, interior, materials and colours to create one single and consistent design statement.

BMW Group designers consistently focus on the future. Today they are already working on vehicle design we will see on the road only in seven or more years. In the process they seek to sense and anticipate how society will develop and what such a development means for the automobile.

Designers get their inspirations from many sources – just as they use a wide range of different tools and instruments. Architecture, art, visits to the museum or a simple walk through nature – this is where inspiration comes from. Then the designers turn their ideas into reality through sketches, true-to-scale models or virtual renderings of a vehicle. Reaching the end of the initial design phase, the interior and

exterior designers work mainly on clay models in full 1:1 scale. Together with specially trained modelers they keep on refining their drafts elaborately by hand until each surface and each line is perfect.

Various design teams compete with one another from the start, and only the best sketches are converted into clay models. These models then provide the starting point for rounds of decision-making in which the Senior Designers and the Board of Management decide which drafts should remain in the contest. Going through several such rounds, the number of contenders decreases continually until in the last round the final design of the production model is chosen from the two finalists.

### Synthesis of form and function

With all specialists in the project team communicating with one another beyond the borders and confines of individual departments, conflicts of interest in terms of design, construction and production technology are recognised and may be solved at an early point. In the process of design/technology convergence, the essential point is to find a synthesis of form and function ideal for all purposes, guaranteeing full function of the vehicle without foregoing any of its characteristic design features. To do this specialists in design/technology convergence carefully consider all factors influencing the design, the surface structure, the function and impact of the various components.

BMW Group designers are also included in development projects carried out by other departments. In seat development, for example, material and colour designers work on the design of the new seat and its appropriate integration into the interior of the car, while the seat department as such works on the structure of the seat in technical and functional terms. Ultimately, such cooperation creates an all-round and truly innovative seat concept which may be quickly implemented and integrated through such an interdisciplinary approach and the know-how shared.

## The Virtual Innovation Agency – Do You Have an Idea?

The VIA Virtual Innovation Agency is an interactive and dynamic interface between pioneers in innovation all over the world and the BMW Group. Using this platform, creative minds are able to present their ideas directly to the BMW Group. So whether the contributor is an inventor, a college, university or private company, no idea is too insignificant or too small. For any idea which is really good is always welcome to approval by the BMW Group and successful implementation in future.

**[www.pioneering-innovation.com](http://www.pioneering-innovation.com)**

### **Information in the internet**

#### **BMW Group**

[www.bmwgroup.com](http://www.bmwgroup.com)

#### **BMW**

[www.bmw.com](http://www.bmw.com)

#### **MINI**

[www.mini.com](http://www.mini.com)

#### **BMW Group Research and Development**

[www.bmwgroup.com/rd](http://www.bmwgroup.com/rd)

#### **BMW Group Sustainability**

[www.bmwgroup.com/responsibility](http://www.bmwgroup.com/responsibility)

#### **BMW Group Technical Encyclopaedia**

[www.bmw.com/techniklexikon](http://www.bmw.com/techniklexikon)

#### **MINI Technical Encyclopaedia**

[www.mini.de/techniklexikon](http://www.mini.de/techniklexikon)

#### **BMW Group Designworks USA**

[www.designworksusa.com](http://www.designworksusa.com)

#### **BMW Car IT**

[www.bmwcarit.de](http://www.bmwcarit.de)

#### **BMW Group Technology**

[www.bmw.com/efficientdynamics](http://www.bmw.com/efficientdynamics)

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#### **BMW Group Research Portal**

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