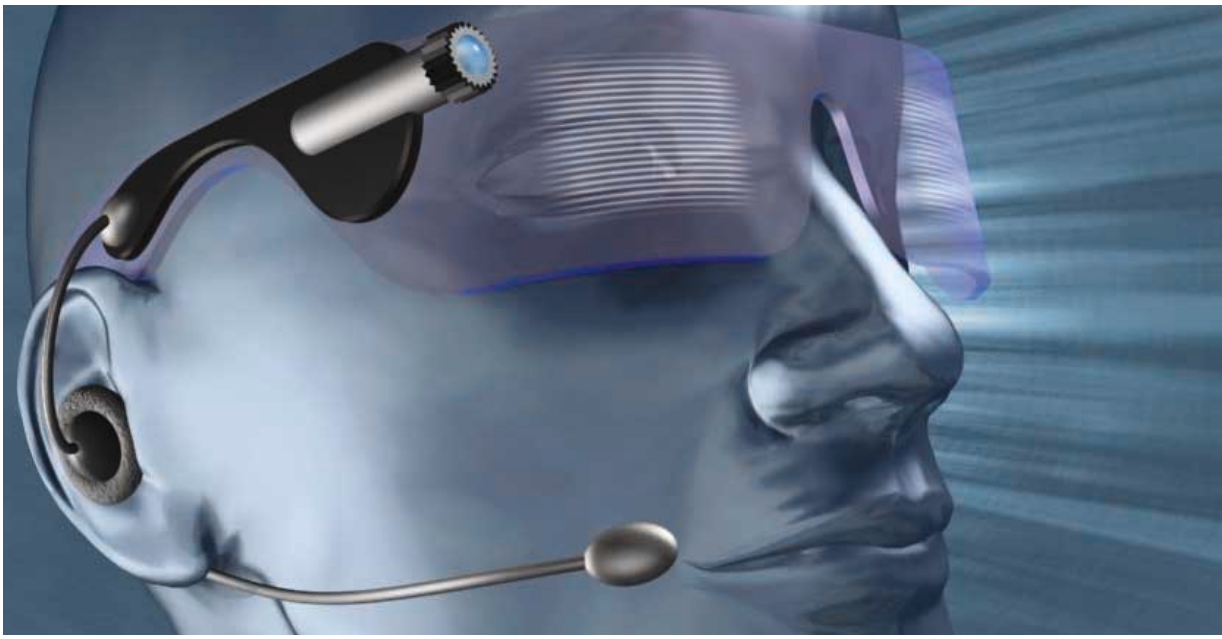
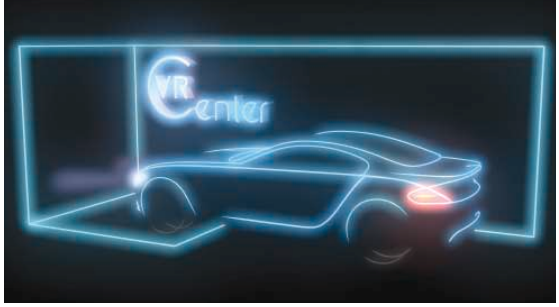
BMW Group
Information
May 2003

Virtual Reality in Car Production.

Using high-performance computers, the automobile manufacturer is now in a position to simulate many steps in the development process realistically on the screen before building elaborate models and using expensive test stands. And this option to work with computergenerated simulations is not limited to conventional screen displays alone. Virtual reality used by the BMW Group from the initial development of design concepts all the way to planning production processes is a most efficient and innovative simulation technology.



BMW Group



The Virtual Reality Centre opened at the BMW Innovation and Research Centre in 2001 pools all of the BMW Group's VR activities.

Virtual reality known as VR for short is also referred to as "reality simulated by the computer" or as an "artificial world". To create this world, high-performance computers convert huge amounts of data into spatial, three-dimensional images, giving the observer the same sensory perception as in reality – the virtual world looks "real". Indeed, such a virtual world is able to replace "real life" in many areas and applications, particularly if it serves to simulate only a precisely defined excerpt of reality.

The virtual future of the automobile has already begun.
The cyberspace world has already developed from simple games to a very serious and meaningful industrial tool. The user is able to move around in a virtual environment, interacting with and ultimately even shaping the "world" around him. Modern VR studios have what is commonly called a Cave Automated Virtual Environment or CAVE for short – an "electronic cave" in which the observer is surrounded by up to six walls presenting pictures projected in real time. Wearing special glasses, the user then receives a spatial, three-dimensional impression of his virtual environment.

A car becomes virtual reality.
In order to test new vehicle designs and concepts, the VR engineer takes data saved in the computer and calculates the first 3D model on this basis. In the process the computer subdivides the vehicle into a multitude of triangles referred to as polygons. In other words, the computer superimposes a virtual network describing the geometry of the vehicle on to the underlying design and configuration. Then specific colours and surface features are allocated to the individual components according to their actual characteristics and properties. The last step, finally, is to present the highly realistic result to the observer in real time from individual angles and perspectives.

Working in the virtual "CAVE", engineers with 3D glasses "see" the interior of a car on the walls and floor of the CAVE in a genuine three-dimensional experience adjusting to their movements.

From the initial idea to the series product – faster and more efficient than ever before.
Virtual simulation is indispensable today also in the automotive industry. While several prototypes had to be built in the past to test components in advance, planners, designers and engineers now work on one and the same digital model, optimising this model on the screen and, if necessary, transmitting model data via data lines simultaneously to locations all over the world. This reduces the cost of development and, in particular, speeds up the development process, providing faster time to market. A further advantage

Via glasses and a data glove, the movements of the VR master (left) are transmitted to the computer for subsequent calculation and optimisation of the electronic simulation process (right).

The high school of virtual simulation.
The complicated approach taken in generating a virtual world serves a definite purpose: To provide a clear overview of what would otherwise be a sheer myriad or maze of data and to create a style of visualisation open to human sensory perception. If all this data were printed on paper as a list of numbers and figures, nobody would have any idea of what they are "seeing". So it is only conversion into spatial, three-dimensional presentation which is able to combine the still unparalleled ability of the human brain to process images intuitively with the computing power of a large, high-performance computer.

In many areas, however, purely visual presentation is often not sufficient – for example in judging the acoustics, control functions and safety of a vehicle or its individual components. In such a case everything depends on the material of the component used and its properties. So following thorough analysis, the computer applies huge amounts of information to describe the future vehicle with a high standard of precision.

The engineer is able to consider the vehicle in the virtual world from every angle, "cutting through" the vehicle wherever he wishes, conducting measurements, moving around inside the vehicle, and enlarging or reducing the size of the image. Using appropriate software, he is even able to "drive" the car in virtual reality, checking out the noise and sounds generated in the process. In addition – and this is indeed the high school of VR – he can even "drive" the virtual car as, say, a driving simulator directly in a virtual environment, thus testing the qualities and features of specific technical components "on the road" without endangering other road users. And last but certainly not least, crash tests involving the complete car can also be conducted today in the virtual world.

Super-computer and Co.
Sophisticated and highly specialised software is required in order to use and capitalise on all these options. And indeed, immense computer power lurks within the ultra-heavy special glass powerwall at the Virtual Reality Centre (VRC) in BMW's Research and Innovation Centre:

The "walk-in" cockpit: Test persons wearing 3D glasses sitting in front of the powerwall assess various new design alternatives. The control unit is at the front right.

A computer incorporating several processors handles the huge flood of data, large projectors transmitting images with pixels presented in ultimate precision down to the last millimetre on to projection walls from behind.

Wearing special glasses, the user then "dives" into this projected environment, such "shutter glasses" allowing the right eye to see only the stereo image on the right, the left eye only the stereo image on the left. These two images then change immediately whenever the observer varies his position or angle of perception. And using a 3D mouse or a 3D joystick, the user is able to "move around" in the virtual world, sensors following each of his movements and immediately creating the right perspective. This process is referred to as "real time", computer power enabling the user to interact with the image and respond intuitively to everything he perceives.

Beautiful outside, practical inside.
Just like a number of smaller VR studios operated by various departments, BMW's Virtual Reality Centre serves a whole range of different purposes: Designers assess the geometry of specific components,

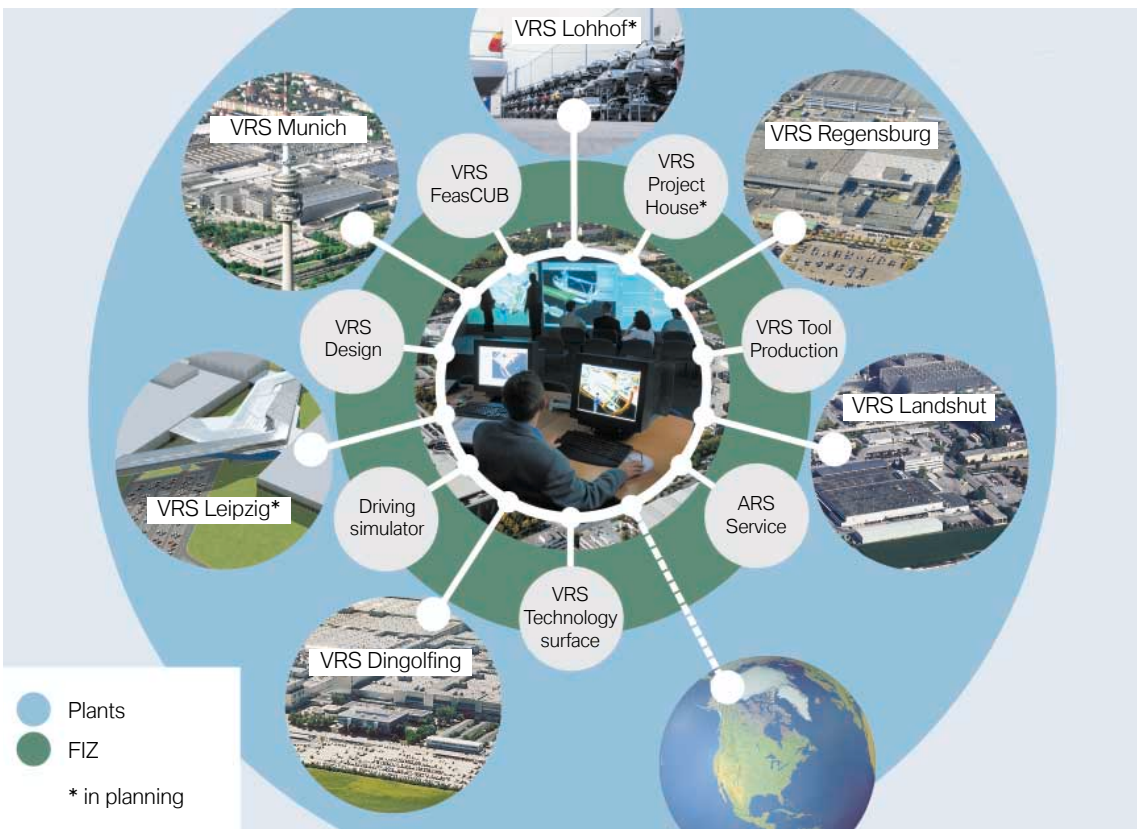
engineers in the Package Department examine from the powerwall how they can use even the last millimetre of space inside the car, and ergonomic requirements are given particular attention in simulating the vehicle's interior. "Sitting" in the virtual car, real people are able to test whether, say, the cockpit elements are perfectly arranged and whether they are still easy to read under various light conditions (or whether they might possibly reflect the light). Engine development specialists are able to examine weak points in the engine in a process of simulated interaction at a stage in which the engine itself only exists as a set of data. Acoustics specialists, finally, make the "data car" oscillate and aerodynamicists test the car in a virtual wind tunnel, optimising its shape and design in the interest of minimum air drag.

Virtual dummies help to save lives.
VR plays a particularly important role in safety research, allowing the user to simulate processes which would be too expensive or dangerous to test in reality. Even before BMW builds a new car the first time, it has already been "crashed" at least 100 times in all kinds of ways in the virtual world. The computer takes 2 – 4 days to simulate a head-on collision against a wall, operating day and night in the process and subdividing the tenth of a second in actual the impact into increments each lasting just a thousandth of a second. This creates a kind of silent "movie" with the car pushing against the wall in millimetres and being deformed so gently in the process as if it were made of plastilin.

This procedure saves a lot of time, since a "real" prototype car costs up to three-quarters of a million Euro. By comparison, a computer "crash" of the type described costs only about Euro 400.-, despite the long computer time required. So although development engineers building a new model require more than 1,000 virtual test runs, this process is still significantly less expensive than one single real-life test. A further advantage of simulated tests is that the engineer can check out different variants without the risk of harming human health or damaging material. Real-life safety tests are nevertheless still required by law in order to verify the reliability and accuracy of computer calculations.

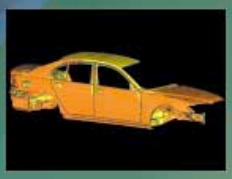
The virtual factory.
Not only the individual vehicle is an ideal object for cyberspace technology. On the contrary – BMW's production specialists now design entire press shops and paintwork facilities in virtual space, presenting and assessing, say, every body panel as well as the tools required for its production in their original size.

Engineers in Planning, Development and Production use virtual reality to see how the sheet metal is drawn over and shaped by the virtual tool. Such simulation models are indeed ideal for ongoing analysis and improvement of body panels without having to build elaborate models. Different colours are used to characterise the thickness of the sheet metal tested, enabling the engineer to optimise possibly critical points step-by-step.



The BMW Group's VR and AR infrastructure: Using fast transmission lines, specialists at the plants and the VRC are able to exchange data in real time. This system is to be internationalised in future.

AR in service



Drier simulation

Simulation of installation/ assembly

Service

Development

Surface quality

3D plant planning

Simulation of components

Simulation of workers

Package simulation

Sales

Production

Virtual showroom

VRC infrastructure

Simulation of reflections / light conditions

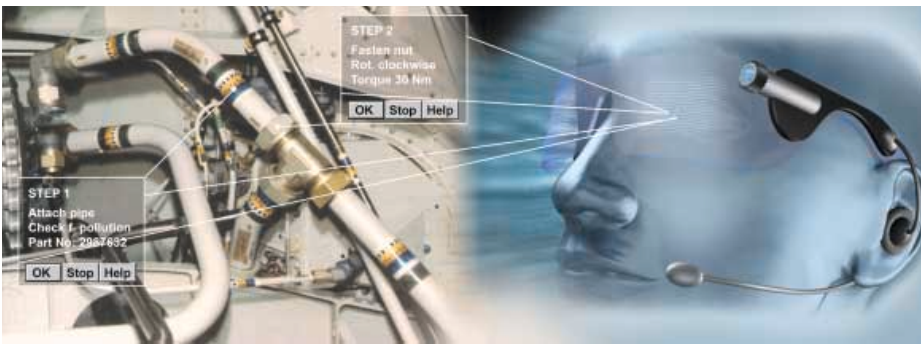
Simulation of driver ergonomics

Application of virtual reality by BMW:

Virtual reality is indispensable today in many areas ranging from Development through Production all the way to Sales and Service.

Traffic jams in a computer.
Computer simulation even serves these days to realistically test traffic scenarios and try out countermeasures before they are applied on the road. Using realistic simulation models, the tester is able to examine systems which in the real world can either not be examined at all or only with an immense effort. BMW thus uses these tools for a wide range of purposes and applications – from the examination of driver assistance systems all the way to traffic telematics.

From seeing to touching.
Optical presentation of virtual reality is now the main feature of all VR technologies. But in some areas even this is not sufficient. In future, therefore, the computer and the data glove might even be able to generate a genuine "hands-on" experience for the VR user, enabling him to virtually "touch" the object involved. This would allow, say, the realistic examination of individual vehicle components, as well as the installation of and accessibility to individual elements in production.



Training for installation and repair: Using augmented reality, the computer feeds in instructions and additional information for precise planning and execution of even the most intricate manual operations.

The showroom of the future able to present specific features of materials such as leather grain clearly and realistically.

Soon even the process of building a vehicle will be simulated by virtual reality, the result then being fed back immediately to the data-set in the computer. This will again provide a whole range of new applications: Whilst so far the "only" option was to determine specific features and functions of the vehicle, the user will then be able to intervene in the actual design and construction process. This, in turn, will ensure even closer interaction of all processes from design all the way to production.

Augmented reality.
Augmented reality is yet a further step in this development process: With this kind of man/machine interaction, the user "sees" context-related information derived from the object considered right in front of him in his line of vision. Wearing special glasses, a mechanic, for example, is able to see information helping him in his work. This may be maintenance and repair instructions as well as the presentation of actual data for a comparison with the related target data. If, say, the mechanic is required to screw in a bolt, arrows will start to rotate in front of his eyes at exactly the right point. The entire process is controlled by a microphone and voice recognition, a small video-camera on the frame of the user's glasses observing the right position of the components during installation. The image provided by the camera may also be fed to a remote expert able, even from a distance, to give the local user the information he requires in his work.

Augmented and virtual reality are trendsetting technologies in which BMW's Development Division plays a decisive role also through joint ventures in research and development.

© BMW AG
Technology Communications

Further information on the BMW Group is available in the internet:

http://www.bmwgroup.com
http://www.bmwgroup.com/scienceclub