FOR IMMEDIATE RELEASE

David J. Buchko
BMW Product Communications Manager
(201) 307-3789 / dave.buchko@bmwna.com

Gordon B. Keil
BMW Product Communications Specialist
(201) 307-3790 / gordon.keil@bmwna.com

Shaping The Future - Fascination, Innovation, Technology and Motorsport.

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1. Individual Mobility, Dynamic Cars, Responsible Use of Resources - an Inevitable Contradiction in Terms?

The automotive industry is facing a huge global challenge: to reduce fuel consumption and minimize Carbon Dioxide emissions accordingly. And lightweight technology plays a key role in his context. The BMW Group is developing new technologies, materials and processes in order to further improve the efficiency and ecological balance of its cars, whilst naturally maintaining the highest standard of customer benefits. Following this underlying objective in our development activities, we are able in the process to acquire valuable development, production and process-related know-how. Strategic partnerships are of great significance in this context, allowing us to use the most advanced and latest technologies. And since there is no such thing as the "ideal" all-round lightweight material, the BMW Group, focusing on process dependability, product quality and economy, is looking for intelligent combinations of metals and synthetic materials.

A good example of this development is the new BMW 5 Series Saloon with its low-weight aluminum front section, another equally good example is the roof of the BMW M3 CSL made of carbon-fiber-reinforced plastic. The result in each case is greater fuel economy and enhanced driving dynamics. And taking an entirely new approach also in engine construction, we are introducing the world's first composite magnesium/aluminum crankcase.

Preserving the individual's personal mobility is just as important for a car maker, especially with traffic volume growing the world over. Seeking to offer our customers BMW's proverbial sheer driving pleasure also in future, we realize that we must capitalize on the existing transport routes and network. Accordingly, we are working on cars incorporating a multitude of different sensors in order to detect current driving conditions and exchange this information independently and directly with other vehicles. Detecting traffic congestion or local hazards efficiently and in good time in this process, these systems provide extra comfort, greater efficiency, and enhanced safety on the road.

We also derive valuable synergies for developing new technologies from our broad-scale involvement in motorsport, with the additional advantage of a positive, dynamic image not only for the Company and our sporting success but also for our customers. And last but not least, we are able to look back at a long tradition of achievements full of success: BMW has always stood for progress in technology and leadership in innovation. So that now, resting on this stable foundation, we are able to look into the future full of confidence and optimism: Through its innovative power, the BMW Group is perfectly prepared to master the challenges of a successful future also in the long term.

-Dr. Norbert Reithofer, Board Member BMW AG.

2. Shaping the Future. Fascination - Innovation - Technology - Motorsport. (Summary)

Intelligent lightweight technology is the future.
There is no single, all-round solution for lightweight technology efficient in structural, design and economic terms and sensible at the same time in ecological terms. With this in mind BMW Group experts examine and develop the right concepts and combinations of materials with a clear focus on each vehicle project. In this process BMW Group specialists are looking in particular at potentials for saving weight and, accordingly, energy, in conjunction with advantages in design, structural and functional efficiency. Precisely this gives the customer direct benefits and advantages, since the driving dynamics and agility of a car result directly from the right choice of materials. And it is also here that a stable ecological balance leads to a universal, all-round focus on materials and, as a result, meaningful material concepts.

BMW Group clearly defining the use of lightweight magnesium. Thirty-three percent lighter than aluminum and 77 percent lighter than steel, magnesium offers significant potentials in automotive construction. BMW Group specialists have therefore developed this material to an even higher standard, redefining the former limits to the use of aluminum in the automobile. And introducing the composite crankcase based on a combination of magnesium and aluminum, the BMW Group is setting a new milestone in materials and engine technology, the substitution of aluminum by magnesium reducing the weight of the crankcase by approximately 10 kilos. This development already close to series production level will be entering regular production in the next two years.

Intelligent lightweight technology featuring carbon-fiber-reinforced plastics (CFP).
The BMW Group is promoting development and process technologies for the series use of body structures and components made of carbon-fiber-reinforced plastics (CFP). An outstanding example of the use of this innovative composite lightweight material in series production is the CFP roof of the BMW M3 CSL proudly displaying this material at very first sight. This CFP roof built in the world's first highly automated production process for CFP body components at BMW's Landshut Plant offers significant advantages through lower weight combined with outstanding resistance to both crash forces
and corrosion.

So far components made of carbon-fiber and composite carbon materials have served mainly as individual, one-off parts used in aerospace and motor racing applications. But wherever there is a need for light, extra-stiff and very strong materials able to take up substantial loads, designers and construction engineers are using the advantages of carbon-fiber and composite carbon constructions to an ever-increasing extent.

Between reality and the virtual world: Augmented Reality setting new horizons.
Focusing consistently on Augmented Reality, BMW is focusing on a technology, which allows the user wearing data glasses to superimpose virtual, three-dimensional and animated pictures on to a real background. An area where this concept might be used efficiently is service, where the mechanic wearing data glasses is able to superimpose virtual information from the repair manual on to the "real" background to obtain all information in real time on complex processes and keep his hands free for working with maximum efficiency.

ACC Stop & Go Active Cruise Control.
ACC Active Cruise Control complete with a radar distance sensor already helps the driver of the BMW 5 and 7 Series maintain the right distance from a vehicle ahead and keep the appropriate speed on the road. And now BMW test cars even feature an ACC Stop & Go function covering the full range of ACC speed control all the way to a standstill.

To provide this function, vehicles equipped with ACC use radar sensors to cover the entire area in front of the car, both further away and close-up. These sensors determine the distance, the position and speed of vehicles ahead of the driver's car, ACC Stop & Go then using this information to intervene in the drive system and apply the brakes in order to keep the right distance from the vehicle ahead, if necessary, by slowing down the car until it comes to a complete standstill.

Following BMW's underlying philosophy, the driver always remains in control and is able to intervene whenever necessary. A further point is that automatic intervention in the brakes is limited, with ACC Stop & Go requesting the driver in good time to take over whenever necessary.

Car/car communication: a direct dialogue without any infrastructure.
Using ad-hoc communication networks, cars are able to "talk" directly with one another, compiling data from their surroundings, processing the information received and exchanging this input with other cars - quite independently and without requiring any kind of firm infrastructure. This ensures full coverage of traffic information as well as possibly hazardous situations monitored consistently at all times. The big advantage is the optimisation of traffic flow also on side routes as well as the provision of local hazard warnings reaching the road user quickly and reliably.

This car/car communication is based on wireless LAN transmission technology providing the foundation for full coverage ad-hoc networks where the car acts not only as a sender and receiver, but also as an intermediary in transferring information.

Efficient dynamics: overcoming an apparent contradiction in terms.
BMW Group engineers have found the right way to overcome a seemingly insoluble contradiction in terms, thus making the inefficient use of energy in specific situations a thing of the past.

The objective in this development process is to achieve maximum efficiency in dynamics. And this is made reality in the first BMW X5 research vehicle built for this purpose, integrating an electric motor between the engine and the transmission. Boosting the conventional drivetrain when accelerating, this electric motor is able to increase start-up torque to a peak of up to 1,000 Nm, the electric motor and combustion engine thus interacting to achieve unprecedented smoothness and response combined with extra power and performance particularly at low engine speeds. The electrical energy used in this process is derived from kinetic energy stored in capacitors whenever the car is driving in overrun or when the driver applies the brakes. This new technical concept saves the driver up to 15 percent fuel by storing brake energy and supporting and/or reducing loads on the combustion engine under inefficient driving conditions.

Miniature head-up display.
A new technology from BMW's Technology Office in Palo Alto in Silicon Valley revolutionizes communication processes in sailing: a miniature head-up display in the sunglasses of the sailors in the ORACLE BMW Racing Team serves to visually present information directly in the sailor's line of vision.

The big advantage is that the viewer always receives important information right where he needs it, saving valuable time in taking the necessary action and benefiting from an enhanced level of safety. Similar technology is used in Ralf Schumacher's prototype Formula One helmet, and at least in technical terms there are no reasons why this technology should now not be used in everyday motoring. Transfer of technology from motorsport to series production providing greater synergies.

Motorsport sets the benchmark for fast work and precise efficiency. Indeed, this applies particularly to the many engineers and other specialists working on motorsport applications far away from the race track, focusing untiringly on even the smallest technical potential allowing the racing driver to compete with the very best worldwide. Knowledge gained in this process is then used by engineers in series development, ultimately to the benefit of the customer. And in exactly the opposite process, professionals in motorsport are able to capitalize on the wide range of practical knowledge and experience gained in series production.

BMW motorsport: winning races to the benefit of series production.
To ensure success in all disciplines of BMW motorsport in 2003 - Formula One, the European Touring Car Championship, the 24 Hours of Nürburgring, and the promotion of talents in Formula BMW - BMW engineers in series production and motorsport cooperate closely as one team. Indeed, BMW motorsport serves as a kind of high-tech lab in research and development, construction, rapid prototyping, electronics, production, and in other areas. Pressure for performance straight from the race track serves to speed up and optimize developments in Munich, and the know-how of BMW's series production engineers forms a strong and stable foundation.

The BMW Group: a great heritage of innovation.
The BMW Group has always seen innovation as a guarantee for success on the road and in business. In many areas, particularly in engine technology and electronics, BMW was and still is the pacemaker for new technologies.

And the list of achievements is truly impressive, ranging from the first electronic speedometer with a fuel consumption indicator and Check/Control through the world's first electrohydraulic anti-lock brake system (ABS) all the way to the introduction of xenon headlights and the ITS head airbag in the 7 Series. A particularly outstanding example of such developments in engine technology, in turn, is the BMW Group's fully variable VALVETRONIC valve control.

Proceeding from this experience, the BMW Group will continue to actively shape the future, already paving the way for environmentally compatible mobility back in 1994 with the world's first series production of dual-mode natural gas cars. Then, on the occasion of the Expo 2000 World Fair, the BMW Group presented the first fleet of 15 BMW 750hL research cars featuring a hydrogen-powered combustion engine. In the meantime BMW is already working all-out on the first series production car in the world with hydrogen drive.

3. Magnesium - A Material with Great Perspectives.

- BMW Group developing new, trendsetting options for the use of magnesium.
- World's first composite magnesium/aluminum crankcase for a water-cooled engine; magnesium alloy with new features and properties.
- Landshut Plant acting as the Competence Center for Light-Alloy Casting in building the instrument panel structure for Rolls-Royce.
- Leadership in production technology thanks to in-house know-how.

Magnesium is not only one of the most common elements in the world, but can also be recovered, inter alia, through electrolysis. In its pure form, with a density of 1.81 grams per cubic centimeter, magnesium offers a significant advantage over both aluminum (density 2.68 grams/cubic centimeter) and steel (density 7.87 grams/cubic centimeter) in terms of weight.

Magnesium - the ideal lightweight material?
Magnesium nevertheless has some features, which limit its possible use in the automobile. Whenever it comes into contact when wet with other materials such as iron, for example, magnesium is subject to a greater risk of corrosion. Depending on the alloy used, a further point is that magnesium may tend to creep under load at high temperatures. This is why magnesium in its pure form or as a conventional alloy is not suited for permanently conveying high loads and forces of the kind typically encountered in central components of the engine. So far the use of conventional magnesium alloys has been limited to components and applications subject to only a minor risk of corrosion as well as thermal or mechanical loads kept to a minimum.

A milestone in lightweight technology: the world's first composite magnesium/aluminum crankcase.

In the meantime the BMW Group has made a genuine breakthrough in technology, developing the world's first composite crankcase made of magnesium with a cast-in aluminum insert. This makes the BMW Group the first manufacturer of a water-cooled combustion engine using the substantial weight benefits of magnesium and at the same time overcoming the drawbacks of this very light material. This composite crankcase for a straight-six power unit is a series-based development scheduled to enter regular production in BMW power units in the next two years.

Weight down by one-quarter.
Substituting aluminum by magnesium, BMW is able to reduce the weight of the crankcase in the same design and structure by approximately 10 kilos. Clearly, this offers

a further potential for reducing the weight of future car generations, always in consideration of the fact that less weight means greater fuel economy. And less weight at the right point also improves the dynamic performance and agility of a car.

A detailed look at the composite crankcase.
A crankcase made of pure magnesium or a conventional magnesium alloy is not suitable for series production for the simple reason that the limited transfer of forces and the associated creeping effect of the material as well as the surface qualities of the cylinder liners present insurmountable obstacles. Precisely this made it essential to find a combination of materials and components designed to meet all requirements and demands in practical use. In principle, the structure and configuration of this unprecedented composite crankcase follows the design of BMW's new generation of four-cylinder power units with VALVETRONIC valve technology. And to optimize the engine's structural stiffness, acoustics and fatigue strength, the crankcase is split down the middle on the level of the crankshaft bearings.

The differences versus an all-aluminum engine become quite clear right from the start, the composite crankcase incorporating an aluminum insert surrounded by magnesium in the upper section of the cylinder liners and water cooling jacket. With this aluminum component efficiently resisting even high thermal and mechanical loads, it comprises the bolts and connections for the crankshaft bearings and cylinder head. The magnesium housing surrounding the aluminum insert, in turn, serves primarily for the oil ducts and the connection of ancillary units. Various functions have been integrated here and the number of ancillaries reduced, the gearbox cover as well as the mounts for both the alternator and vacuum pump being integrated in the housing. The lower section of the crankcase, in turn, also made of pressure-cast magnesium, comprises cast-in sintered steel inserts for the crankshaft mounts.

New sealing systems have been developed for this new engine concept excluding the risk of corrosion along the seams. To avoid contact corrosion between magnesium and steel, finally, the crankcase features special high-strength bolts made of aluminum.
Magnesium alloy with new features and properties. Apart from production and procedural know-how combined with maximum dependability in all processes, the right combination of materials is an essential prerequisite for successfully building a truly innovative composite crankcase.

After thorough basic research in close cooperation of specialists in materials technology, engine development and light-alloy casting at the BMW Landshut Plant, the experts have modified an aluminum alloy to meet the specific requirements of a crankcase in the power unit. This re-defines the borderline for the use of this material and opens up completely new, unprecedented areas of application.

In developing this new material, the focus in particular was on creep resistance, corrosion behavior, thermal and mechanical loads, casting behavior, the avoidance of contact corrosion between magnesium and other materials, as well as prevention of any leakage or spillover from or to the engine. The skills required in mastering the processes involved were established at the same time in the Pressure Casting Technical Center of BMW's Landshut Plant and the complex production process was secured accordingly. Specialists within the BMW Group itself developed the know-how required for the materials and processes involved, learning to mastermind all process requirements.

The big challenge: casting the composite crankcase.
Developing the technology for production of the composite crankcase, the light-alloy foundry at BMW's Landshut Plant faced new challenges in process engineering. Particularly the need to handle the different thermal elongation of aluminum and magnesium called for a high standard of technology requiring, in turn, all the experience of BMW's foundry specialists. With the newly developed casting process, the magnesium jacket shrinks on to the aluminum insert while cooling, the core being permanently anchored within the magnesium jacket by ribs with positive engagement.

With aluminum and magnesium requiring roughly the same period to grow solid at a temperature between 500 and 600 °C, the actual casting process calls for very elaborate thermal management to ensure that the mold and the insert are heated up and cooled down in parallel at exactly the right time.

Impressive production technology.
The new crankcase is manufactured on one of the world's largest pressure-casting machines at the Pressure Casting Technical Center of BMW's Landshut Plant. Following an automatic process, a separating agent is first applied on the two-piece mold weighing almost 60 tons, before the aluminum insert is placed in position and the mold is closed. The pressure-casting machine controlled in real time then compresses the liquid magnesium at a temperature of approximately 700 °C and a pressure of almost 1,000 bar into the remaining cavities in the mold within a mere 6/100ths of a second, the two halves of the mold being held in place under a force of approximately 4,000 tons. This makes the metal turn solid within 10 seconds, a robot then removing the crankcase from the mold after 20 seconds. Following the casting process the crankcase goes through a process of heat treatment prior to further machining and finishing in order to reduce internal tension.

Magnesium in series production.
The use of magnesium does not call for any significant changes or modifications of the production process - neither in the foundry nor in the subsequent process of machining the combination of materials - in comparison with all-aluminum components, since

magnesium is easy to machine and process with maximum efficiency. In the use of coolants and lubricants, in turn, and in the disposal of chips and metal residues, the BMW Group benefits from many years of know-how provided by experienced partners in the materials and automobile industry. Materials are therefore recycled with optimum efficiency in the interest of the environment and superior economy.

Fully automatic production of the composite crankcase is currently being optimized and raised to the highest standard in the pilot facility of the Pressure Casting Technical Workshop at the Landshut Innovation and Technology Center. Within the next two years the production process will be moved to the significantly enlarged light-alloy foundry in Landshut for series production of the composite crankcase. Currently the BMW Group is investing more than Euro 100 million in this extension of pressure-casting operations covering an area of more than 10,000 square meters.

Magnesium in lightweight production - already a standard feature wherever appropriate.
The BMW Group has been using magnesium components where appropriate for a number of years. Some examples are the instrument panel support in the MINI manufactured through pressure-casting, the steering wheel skeleton and the steering column support of the BMW 5 and 7 Series, the housing of the fully variable intake manifold featured on BMW's 8-cylinder power units, the roof compartment lid on the BMW 3 Series Convertible, and engine components on BMW motorcycles.

Complex and sophisticated: The instrument panel support on the Rolls-Royce Phantom.
Understandably, Rolls-Royce Motor Cars Limited, one of the BMW Group's most outstanding subsidiaries, uses only the world's best competence centers for trendsetting achievements in technology. And precisely this speaks in favor of the particular skills in production and development offered by the Landshut Plant. Here, BMW's casting specialists build one of the largest pressure-cast magnesium components throughout the automotive industry - the instrument panel support for the Rolls-Royce Phantom. Incorporating numerous functions such as the opening duct for the airbag, the air pipes and flow ducts, mounting points for the air conditioning, as well as fastening elements, this highly stable support element is both complex and sophisticated in design. But at the same time the integration of so many functions in one unit helps to reduce weight to a minimum and enhance the benefits involved to a maximum, the magnesium support weighing a mere 7.6 kilos. And since the entire unit is cat in one piece, production tolerances are even smaller than on a welded structure made up of several parts.

4. CFP - Another Material with Great Perspectives.

- BMW Group working all-out on the regular use of CFP in series production.
- CFP body components offer a lightweight potential of 30-50 percent.
- Innovative processes at the Landshut Plant:

Automated CFP production.

- The roof of the M3 CSL - an outstanding example of lightweight CFP technology in series production.

The BMW Group is working all-out on the processes and technical skills required for the series production of body structures and components made of carbon-fiber-reinforced plastic (CFP). Particular highlights in this context are the special design and configuration of the individual components built for specific models, simulation and testing procedures, as well as process-related issues such as the automation of production and the ongoing development of the materials used.

An outstanding example of how this innovative lightweight composite material may be used in series production is the CFP roof of the BMW M3 CSL proudly boasting the very special look of this material: This roof is made at BMW's Landshut Plant in the world's first highly automated production process for CFP body components.
Already used today to meet the most extreme requirements.

So far carbon-fiber or composite carbon materials have been used mainly for individual components in aerospace and motorsport. Particularly where the material used has to withstand heavy loads whilst keeping weight to a minimum and thus offering supreme stiffness and strength, designers and construction engineers now use carbon-fiber-reinforced plastics to an increasing extent. The monocoque of the WilliamsF1 BMW FW 25 Formula One racing car, for example, is naturally made of this ultra-strong lightweight material.

Low weight, superior strength.
Carbon-fiber-reinforced plastics offer a significant potential for reducing vehicle weight also in "regular" production cars, CFP being highly suited for body components due to its superior strength and stiffness. The body of a modern automobile, depending on the model, accounts for 15-20 percent of the overall weight of the car. Body components made of CFP, in turn, are up to 30 percent lighter than aluminum and 50 percent or more lighter than steel. So depending on whether CFP is used for individual components or for the entire structure of the body, this highly sophisticated material is able to reduce the overall weight of the car by up to 10 percent, without making the slightest concession in terms of stiffness and body strength. Clearly, this improves the car's performance and agility whilst reducing fuel consumption at the same time.

CFP - a unique material with unique qualities.
Apart from the significant reduction of weight, the biggest advantage offered by carbon-fiber body components is their exemplary behavior in the event of a collision ensured by superior strength and stiffness. With these qualities of carbon fibers measuring only about 0.007 mm in thickness coming to bear primarily in the directional flow of the fibers themselves, the particular features and properties of CFP components can be optimized and adjusted to anticipated forces and load conditions by choosing the right alignment and building up fiber layers resting on one another.

CFP offers new potentials.
A further advantage is that CFP may also be used for highly integrated and extra-large body components requiring very complex processes when made of aluminum or steel plate. This, in turn, offers significant advantages in the design and construction of the body, with various functions such as mounts and supports being integrated directly into the component itself. Even complex structural components or complete body modules may be made in one mold, significantly reducing the number of individual components required on the body of the car.

CFP in a solid bond.
One of the methods used by the BMW Group's CFP specialists today in connecting parts and components is bonding or gluing technology, a process which allows combinations of various materials in individual components and modules. Bonding technology using high-strength glue has indeed already proven its qualities with steel or hybrid car bodies, glue being used to a greater extent than before to connect individual body components on the new BMW 5 Series.

Positive ecological balance.
Sustained, environmentally compatible and conservative use of resources is a major factor from the start in developing new BMW Group car concepts, comprehensive ecological case studies serving to assess innovative lightweight concepts from virtually every angle. Focusing on various scenarios, BMW Group experts have determined that CFP bodyshells or body structures, by reducing fuel consumption to an above-average extent during the use of a vehicle, are able to offer significant benefits in terms of their ecological balance.

Efficient CFP recycling and waste management.
Various recycling and waste management concepts have been compiled and assessed in the course of the development process both for production waste and for CFP waste from end-of-life vehicles. BMW Group specialists have developed a technologically and economically meaningful recycling concept for production waste made up of just one

material, which is particularly significant, understandably, in the case of high-cost carbon-fiber.

A consideration beneficial to the environment in the use of end-of-life vehicles with CFP components is that such components are made primarily of petroleum derivatives such as resin, carbon-fiber and glue. Ecological balance studies have shown that the economically and ecologically most appropriate option in recycling CFP components from end-of-life vehicles is to use such components either to recover the materials as such for subsequent use and/or to use these materials for generating energy. The usual process of materials recycling, that is the high-cost disassembly of structural components in end-of-life vehicles followed by a complex process of ecological reconditioning, is not advisable in this case.

Breakthrough to automated series production.
So far the expensive production process has been an obstacle in the series use of CFP body components in the automobile, such components using a relatively "young" material being made largely by hand in an elaborate and time -consuming process: The carbon tissue is applied by hand in individual layers and then coated with resin, before the finished component is hardened for several hours in a special furnace.

Now, in a thorough process of developing both the materials and technologies required, the BMW Group's CFP specialists have succeeded in the last two years in improving and automating the production of CFP components at the Landshut Plant, paving the way for economical, high-quality series production of carbon-fiber body components. This sets the foundation for the increased use of carbon-fiber materials in a modern automobile.

The roof of the M3 CSL - a truly outstanding example.
Conceived and engineered in close cooperation with the CFP specialists at the Landshut Plant, experts at BMW's Research and Innovation Center, and the automotive engineers at BMW M GmbH, the roof of the BMW M3 CSL is an outstanding example of the use of lightweight materials enhancing the body structure and proudly boasting their qualities. At the same time this is the world's first series application of the new production process. Apart from the stability required of such a components, the finish and surface look of the material demand the utmost of the production process, with clear-coat paintwork visibly displaying the tissue structure of the CFP material.

The roof of the BMW M3 CSL is made in pilot facilities at the two plastic body skin and CFP Technical Centerss of the Landshut Plant in a three-stage production process: Step 1 is to place the five layers of special carbon fibers on top of one another for pre-forming. A particularly important requirement in this context - and one of the most significant innovations in the process - is to ensure that the carbon fibers are properly aligned, come

in the right position and have the right structure to give the roof the stability and looks required. The second step in production is the RTM (resin transfer molding) injection process, where the pre-formed, multi-layer carbon-fiber mat is placed into the 1,800-ton press, with transparent epoxy resin being injected into the material. The roof then hardens in the heated mold, subsequently being removed by a robot and coated by clear paint.

The result is truly impressive in two respects: First, the time required for manufacturing the roof is less than one-fifth of the time otherwise required thanks to the largely automated production process. Second, the roof of the M3 CSL is 6 kilos or more than 50 percent lighter than a comparable roof made of steel.

5. Formula One Technology Cast in One Mold.

- The Landshut Formula One foundry serving as BMW's competence and prototyping center.
- Maximum change flexibility plus maximum quality.
- In-house process skills and competence.
- Technology transfer from motorsport to series production and vice versa.
- Rapid prototyping technology for short development times.

Rapid action and precision are the name of the game in Formula One.
And indeed, this applies not only to the driver on the race track, but also to everybody involved behind the scenes ensuring the success of the BMW WilliamsF1 Team. The BMW V10 power units featured in the white-and-blue Formula One racing cars acknowledged to be among the best performers in the scene are subject to an ongoing process of change and improvement. For only the manufacturer with the right skills and a high standard of flexibility is ultimately in a position to use even the smallest potentials and compete successfully with the very best.

Networked in-house competence for greater synergies.
In consideration of this great challenge, the BMW Group built a Sand-Casting Technology Center, a highly specialized foundry for F1 engine components, at the Landshut Plant in the year 2000, directly next to the light-alloy foundry for the cylinder heads and crankcases featured in BMW's regular production engines. Just 65 kilometers from BMW Motorsport in Munich, BMW's casting specialists benefit from ideal conditions in making the power units starring in the WilliamsF1 BMW FW 25 the most powerful and reliable machines in Formula One.

Apart from crankcases and cylinder heads for BMW's V10 power unit, the Landshut Technology Center also builds test parts and components, the foundry also serving as the prototype production facility for developing components for the BMW Group's future series production engines. The Sand-Casting Technology Center is manned by an in-house team of specialists coming exclusively from the light-alloy foundry. Given the small number of components and the flexibility required in making changes, experience and craftsmanship are of course an absolute must. The foundry team at BMW's Landshut Plant is closely involved in the process of developing new power units both for BMW Motorsport and for series production.

With the entire process chain from model construction through casting all the way to quality tests coming under one roof, the team is able to respond flexibly and quickly to changes and new requirements. Precisely this is why the Sand-Casting Technical Center has its own model-building department complete with CAD facilities modifying or

building moulds for sand cores. Perfectly coordinated change and quality management in processes and the proximity to BMW Motorsport in Munich even allow the modification of parts and components between two races.

We never take "No" for an answer.
Without losing sight of the need for optimum precision, the foundry team makes the impossible possible every day together with the engine development specialists. And this is absolutely essential, considering that racing engine technology has in the meantime been developed to such an extreme that modifications are only possible with decades of experience provided by specialists in production as well as trendsetting processes and tools. Benefiting from such knowledge and facilities, the foundry specialists in Landshut are able time and again to redefine the limits to casting technology, turning out parts and components with a standard of quality and complexity never seen before.

Although the crankcase and the two cylinder heads are only three out of some 5,000 individual parts that make up an F1 power unit, no other single component in a car involves a more painstaking development process and requires greater competence in process technology.

Outstanding skill in sand-casting.
Manufacturing these two essential F1 engine components, BMW's casting specialists in Landshut have significantly enhanced and upgraded the sand-casting process going back several thousand years in the history of mankind. Sand-casting allows a particularly high standard of freedom in design, combined with superior flexibility in change management and short processing times. In this process liquid aluminum heated to a temperature of 750 °C is poured into a complex sand mold made up as a negative form incorporating up to 50 different sand cores.

Apart from treatment of the molten aluminum and precise control of the pouring rate and temperature during the casting process, the design, production and assembly of these sand cores are all crucial to the quality of the final casting product: The sand cores must properly render both the exterior shape and the subsequent open cavities of the engine component. And reflecting the compact, thin-walled structure of the BMW F1 power unit, the sand cores for the engine components are particularly delicate and refined in their design.

The individual sand cores are put together to form the entire core package exclusively by hand: As if they were working on a three-dimensional - and very fragile - jigsaw puzzle, the casting specialists in Landshut put together the complete casting mold with utmost efficiency and precision, applying years of experience and using all their skill as craftsmen. Indeed, a new core package has to be made for each individual component,

since the lost sand-casting mold has to be destroyed after each casting process in order to remove the ready-cast component.

Rapid prototyping: sand cores with all the speed of Formula One.
A new rapid prototyping technology developed especially for this application serves to speed up the process of building the sand cores. Referred to as selective laser sintering, this technology incorporating a computer-controlled laser beam allows the production of sand cores directly from the engine component's design and construction data, without having to use any molds or tools in the process. The foundry in Landshut uses this rapid prototyping technology also for building the sand cores required for prototype and test engines, helping to significantly shorten the testing period in the development of series production engines.

Superior skills in virtual quality assurance.
The element of chance is totally excluded from the casting process, since both the process of filling as well as solidification are simulated virtually in numerous test series in order to optimize flow behavior right from the start prior to the production of molds, revealing and eliminating potential deficiencies in the process. The filling process as such is monitored by laser technology.

Once the metal has turned solid and cooled down after being filled into the mold, the sand cores are destroyed and the casting set free. Next comes heat treatment serving to provide optimum material properties in terms of tensile strength and elongation. Then, following the most conscientious quality tests, the Formula One components are sent to Munich, where they receive their final touch in the machining process.

Quality always comes first.
Although the pace of change in Formula One is truly breathtaking, every production process must be stable and properly secured. And this is only possible with the help of efficient quality assurance methods, since the only way to obtain reproducible results open for further optimisation is to rule out even the slightest coincidence.

Sample materials taken directly from the melt serve for both quality assurance and computer-tomographic tests of the kind already applied for years in medicine. Such tests allow the engineer to examine all components at the Sand-Casting Technology Center without destroying the parts involved. This, in turn, serves to prove reliably whether the data measured in hollow cavities difficult to reach complies with the design and construction data, or whether there are any defective spots in the material. Landshut even has a Virtual Production Plant to follow up the flow of components in the production process and provide 100 percent quality assurance in Formula One. This means that

even the smallest detail in the production of each individual component may be followed up to avoid even the slightest deviation from the standards required.

Consistent use of synergies in motorsport and series production.
Both the professionals in motorsport and the BMW Group's customers benefit from close cooperation in series production and F1 production technology at the light-alloy foundry in Landshut. Decades of experience in casting components for production engines thus goes straight into the production of F1 components - both the right feeling for materials and production processes and the craftsmanship and skills required. Conversely, the F1 foundry with its extremely demanding standards provides new know-how time and again used directly in the design and construction of series production engines. This ongoing development of casting technology is of crucial significance particularly for BMW diesel engines and high-performance BMW M power units subject to exceptional loads and requirements.

6. Lightweight Technology: Achieving the Right Ecological Balance.

Judging and assessing cars from an all-round perspective with the help of ecology balance case studies, BMW's specialists are able to develop meaningful lightweight concepts saving resources with maximum efficiency.

In creating "intelligent" lightweight developments, experts at the BMW Group's Recycling and Dismantling Center (RDC) keep a close eye on the car concepts of tomorrow, one of their particular interests being ecology balance case studies: In detailed studies of this kind, BMW Group specialists focus on the entire lifecycle of a car and the possible influence of specific concepts and components. Such a process chain analysis is very comprehensive and far-reaching, beginning in the very first stage of vehicle development and extending through the recovery and processing of raw materials all the way to vehicle production and, of course, subsequent use of the vehicle by the customer together with the service required. But since even this does not close the entire circle, the final phase in the lifecycle of a car, that is the process of recycling the end-of-life vehicle, is also taken into account.

All-round perspective.
This all-round perspective shows that some lightweight concepts promising at first sight to significantly reduce fuel consumption thanks to their much lower weight may at the end of the day prove to be less meaningful and beneficial in ecological terms. This is the case, for example, wherever the process of recovering resources and producing the material calls for a lot more energy or generates a lot more emissions than can be saved throughout the entire lifecycle of the car through the reduction of fuel consumption. Another important point to be considered here is the proper recycling of the materials used in line with environmental standards and requirements.

Meaningful concepts to give an intelligent mix of materials a bright future.
In the light of these considerations, ecology balance case studies are exactly the right tool to assess lightweight concepts from every angle. This is why the various combinations of materials used in BMW Group vehicles are all based on a meaningful concept with meaningful qualities. And since there is no such thing as one ideal solution in lightweight technology, the BMW Group will continue to use intelligent combinations of metallic and non-metallic materials also in future.

7. Bringing Together Reality and the Virtual World: Augmented Reality Setting New Horizons.

- Combining the real and the virtual world.
- Virtual animation providing information in a wireless, text-free process.
- Creating an entirely new kind of repair manual.

The BMW Group is carefully studying a technology able to extend the "real" world: With the viewer wearing data glasses, Augmented Reality blends virtual objects and images on to the real-life environment we normally see around us. The viewer wearing such glasses therefore receives additional three-dimensional information supplementing what he is currently looking at.

One possible application of this technology is engine repair, where the mechanic wearing data glasses sees not only the engine as such, but also a virtual animation of tools, components, markings or operating instructions. Such virtual information blended into the picture then guides the mechanic through the complete repair process, the data as such coming from a computer connected to the data glasses. Currently this connection is still provided by a cable transmitting the data required, but in future wireless technologies will take over.

Augmented Reality - a significant innovation in the workshop.
A repair manual upgraded by Augmented Reality makes it much easier to explain and, in particular, understand the work to be done. Recognising the appropriate marks and reference points on real-life components, the data glasses "see" what the viewer is looking at. Then, following each operation, they can feed the virtual information required in each case into the viewer's line of vision.

Voice control ensures even greater convenience in interacting with the system, allowing the user to call up the virtual information required on his data glasses with maximum convenience.

The transmission of information through Augmented Reality provides crucial benefits in service, particularly in the light of growing complexity and a model range constantly becoming larger:

- All information can be called up at any time directly on the car or on the component involved in a mobile, highly flexible process.
- Receiving and taking up information during repair with hardly any text helps the mechanic save precious time.
- The mechanic keeps his hands free for the work actually to be done.

- In all, Augmented Reality ensures a high standard of repair quality.

Field test: from the research lab to the real-life workshop.
The BMW Group cooperates closely with partners from research and the world of business in studying various applications of Augmented Reality. And the BMW Group is indeed the leader in applying this technology for automobile service, a field test planned for the near future at various workshops being intended to provide new findings and experience for the practical use and application of Augmented Reality. Such applications extend throughout the entire field of service, covering the diagnosis of defects and the actual process of repair, where the repair manual provides detailed information on the removal of parts and components as well as the installation of disassembled or new parts.

The next steps in developing Augmented Reality will seek to identify the surroundings and the area the viewer is looking at even without the use of special markers or reference codes. In that case the data glasses would be able to reliably detect the environment without all the components involved being marked in advance.

8. Keeping Your Distance the Comfortable Way: ACC Active Cruise Control.

- Radar sensor detecting vehicles at a distance of up to 120 meters regardless of weather conditions.
- Useful speed range from 30-180 km/h.
- Driver assistance in keeping appropriate distances and speeds.
- Greater comfort on the motorway and country roads.

ACC Active Cruise Control in the BMW 7 and 5 Series enhances the functions of conventional cruise control, helping the driver keep the appropriate distance and road speed at all times. This system not only maintains the desired speed pre-set by the driver, but also, whenever required, monitors and controls the distance to the vehicle ahead on the motorway or a country road.

As long as the lane ahead of the driver is free, ACC Active Cruise Control works largely in the same way as a conventional system. But as soon as the driver encounters another vehicle moving ahead at a lower speed detected by the radar distance sensor, ACC adjusts the distance form the vehicle ahead by modifying the driver's own speed accordingly.

When activated, ACC serves to give gas and apply the brakes slightly with the emphasis on superior motoring comfort. The driver can however intervene at any time or apply the brakes himself. And this is indeed necessary whenever the system reaches its limits, since it is BMW's philosophy to maintain the driver's responsibility in and for his car.
To activate ACC the driver first chooses his "personal" speed in comfortable 10 km/h increments by adjusting a control stalk on the steering column.

ACC is conceived for use between 30 and 180 km/h, the speed chosen by the driver being marked on the speedometer and consistently maintained as long as the vehicle ahead does not require a reduction in road speed.

A 77 GHz radar sensor, serving as the key component in the system, is able to detect vehicles ahead at a distance of up to 120 meters, largely independent of weather conditions. As soon as the driver's car approaches another vehicle from behind, Active Cruise Control adjusts the driver's speed smoothly and precisely to that of the car ahead, at the same time keeping a constant distance the driver is once again able to choose himself from four levels on the control lever.

Following the same mode as if the car were on a free stretch of road, ACC performs this function by masterminding the engine, the brakes and even the transmission. Operation of the brakes is limited to a comfortable 2 m/sec2 quite sufficient for fine adjustment of

the car's speed and distance in maintaining the system function. And should the need arise to apply the brakes harder, the driver is informed accordingly by an optical and acoustic takeover message.

ACC relieves the driver of the permanent and monotonous chore of constantly adjusting the car's distance and speed - a particularly convenient feature above all in dense traffic on the motorway and expressways with road speeds constantly changing, where conventional cruise control is often useless. So now, with ACC, the driver is able to "flow along" smoothly and in relaxed style in such a situation wherever appropriate.

9. ACC Stop & Go: Active Cruise Control for the Low Speed Range.

- Proximity radar with a range of up to 20 meters supplementing ACC radar.
- Extension of ACC function all the way to a standstill.
- No attempt to take control away from the driver.

ACC Stop & Go is a further enhancement of ACC Active Cruise Control already available on the BMW 7 and 5 Series. And now BMW Group engineers are already working on the introduction of a stop & go function extending the useful speed range covered by ACC all the way down to a standstill. This makes it essential to monitor the area directly in front of the car, the sensors used for this purpose being able to detect other road users within a close range of up to 20 meters over the entire width of the car.

To provide this function the long-range 120-meter sensor used with ACC is supplemented by additional close-range radar sensors operating in the 24 GHz band and measuring the distance, lateral position and relative velocity of a vehicle ahead. Using such environmental information, ACC Stop & Go masterminds both the engine and the brakes, supporting the driver on the motorway and country roads by maintaining an appropriate distance from the vehicle ahead and, wherever necessary, even slowing down the car to a standstill. And whilst the sensors also monitor vehicles at a standstill, the primary objective of this control function is to ensure highly convenient and reliable motoring in convoys behind moving vehicles and even vehicles that have come to a stop. Again following the same principle as with "regular" ACC, ACC Stop & Go intentionally keeps the driver in control, enabling him to choose his - or her - distance from the vehicle ahead and intervene whenever he wishes.

A further point is that ACC Stop & Go limits the maximum power of brake intervention to 2 m/sec² at typical motorway speeds whilst applying more brake power at lower speeds. And whenever ACC Stop & Go detects a situation which goes beyond its own limited deceleration function, the driver is informed in good time by optical or acoustic signals.

ACC Stop & Go and ACC serve primarily to provide comfort functions supporting the driver and relieving him of his usual chores. But it is equally obvious that these assistance systems make an important contribution to driving safety on the road. The starting point in the development of ACC and ACC Stop & Go is the BMW Group's ConnectedDrive philosophy, driver assistance systems serving to support the driver to the greatest possible extent and with maximum flexibility geared to each situation. But since such systems should never take over themselves by intervening in the car's controls on their own accord, BMW ConnectedDrive combines the strengths of human skills with the strengths of technical systems to give the driver optimum convenience at the wheel.

10. Talking Cars: Intelligent Cars Exchanging Information by Themselves.

- Enhanced vehicle data recognising traffic conditions and possible hazards.
- Local hazard warnings provided by direct vehicle-to-vehicle communication.
- Efficient communication network not requiring any infrastructure.

Just imagine what it would be like to have a car able to "talk" to other cars around you! What would those cars have to tell each other? The BMW Group is working on autonomous, self-organising communication networks - so-called ad-hoc networks - connecting cars with each other. In this process cars collect local data from their immediate surroundings, process this information and exchange it with other cars.

Fast and efficient:
Local hazard warnings for extra safety.
Real-time hazard warnings are one possible application of such an ad-hoc communication network. Such a warning only makes sense if it reaches the appropriate addressee in good time - and precisely this is the case with extremely flexible and fast ad-hoc networks using wireless LAN (WLAN) transmission technology: Should a vehicle, say, start to swerve out of control in a bend due to oil on the road or black ice, it will immediately send an appropriate warning to all other road users in the vicinity currently approaching this bend. Similarly, a vehicle can send out a warning to other cars in foggy weather before they run into a fogbank themselves.

An intelligent computer system decides whether and when a car is to transmit a hazard warning to another vehicle. With a modern car holding a wide range of data over and above its road speed and local coordinates - information from the low- and high-beam headlights, from the foglamps or brake lights, as well as data from the ABS anti-lock brake system, DSC Dynamic Stability Control, the windscreen wipers, or the external thermometer - the computer is able to gather and collect such Extended Floating Car Data (XFCD), turning the car into a virtual sensor "floating" along in the traffic. This data may then be used to determine traffic, driving, and weather conditions. A suitably programmed algorithm is subsequently able within fractions of a second to "sense" the current situation of the car, reliably monitoring weather conditions, the flow of traffic, road conditions and the car's surroundings - for example whether the road is slippery, whether there is fog, whether conditions are wet, or whether there is a traffic jam ending in a bend up front.

A concrete scenario: Activation of ABS and DSC at a low road speed and with the brake pedal pressed down only slightly, in conjunction with a low outside temperature, may be indicative of black ice in the area and the risk of the car skidding. BMW Group research vehicles are already equipped with this technology and, as a function of the data

provided, transmit a hazard warning wherever appropriate by WLAN to other test vehicles. The vision of BMW Group engineers is to set up a comprehensive network of cars able to communicate independently with one another, each vehicle - depending on the situation - serving as a transmitter, receiver, or router.

Fast and ensuring full coverage: Dynamic navigation with real-time information.
Ad-hoc networks enhance the benefits of dynamic navigation systems, for example by transmitting information on obstacles suddenly looming up ahead as well as road incidents very quickly to all vehicles approaching the crucial spot. In a similar way a car leaving a parking space at the side of the road may pass on a signal to drivers in the vicinity looking for a place to park. The main advantage of such ad-hoc networks is however is the full and complete coverage of traffic information optimising the flow of traffic not only on the motorway and main routes, but also on secondary roads and all around town.

In addition, ad-hoc networks provide the basis for an entirely new service one might possibly call a "follow-me function" when driving in a convoy, with individual vehicles informing each other of their current position and route. On his or her navigation screen, the driver sees not only his own position, but also that of other vehicles in the convoy, vehicles following from behind therefore conveniently and safely keeping on the route of the vehicle ahead.

Digital mobile communication providing a quantum leap in technology.
Digital wireless communication in ad-hoc networks ensures a significant leap in technology: for more than 100 years the exchange of information among road users has been limited to simple optical and acoustic signals using direction indicators, hazard warning flashers or the horn of a car. Clearly, the precision and scope of such information is inadequate in many situations, with even cellular networks such as GSM or radio-based information not providing a suitable remedy, since such cellular networks are both relatively expensive and limited in their capacity to transmit data to several users.

Radio-based broadcasting networks, in turn, are not the appropriate method for transmitting individual data and information. Ad-hoc communication networks based on wireless LAN technology for the first time provide the possibility to "release" the driver from his isolation, providing all the information required at the right time and in the right form. The advantages of such an ad-hoc network are obvious, since the multi-hopping process gives them a virtually unlimited range and they do not require any infrastructure, the car itself serving not only as the sender and receiver, but also as the router. A further important point is that mobile users of such a network are able to take their own well-considered decisions on the basis of appropriate, dynamic information generated and made available in real time.

Networking the driver, the car and the surroundings: The philosophy of BMW ConnectedDrive.

BMW is studying and developing the introduction of ad-hoc networks as part of the Group's ConnectedDrive Project: ConnectedDrive seeks to intelligently network the driver with his car and the surroundings, thus making road traffic safer, more efficient, and more comfortable. To be specific, this means the ongoing development of future telematics and online services as well as driver assistance systems.

11. Efficient Dynamics: Up to 1,000 Nm Torque on 15% Less Fuel.

- Much more power on far less fuel.
- Efficient use of kinetic energy.
- First BMW research vehicle opening up new horizons.

Much more power on far less fuel: Precisely this apparent contradiction in terms is solved by a special BMW Group research project. Focusing on the philosophy of efficient dynamics, BMW Group engineers seek to eliminate inefficient driving situations with high fuel consumption. The problem is that stop & go traffic and acceleration, in particular, consume a lot of fuel even with the very best combustion engine. A further point is that application of the brakes converts valuable kinetic energy into useless heat.

A further general point is that the combustion engine is able to develop only a fraction of its nominal output at low speeds (e.g. only about 15-20% of its maximum output at 1,000 rpm). One solution is to integrate an electric motor between the combustion engine and the transmission, helping to boost the engine when accelerating.

Applying this concept, a BMW X5 test vehicle is able to develop start-up torque of up to 1,000 Nm. Then, as soon as the combustion engine has reached its midrange speed and therefore develops enough power, the electric motor is cut back. Working as a team, the electric motor and combustion engine provide a response never seen before, boosting engine torque to an unprecedented level above all at low speeds. The energy required for the electric motor is delivered by an electrostatic high-performance energy reservoir free of wear. Made up of double-layer capacitors, this reservoir is able to store and build up kinetic energy while driving, that is the energy generated when the driver applies the brakes or when the car is in overrun. This keeps the system independent of any external sources of energy and even provides energy not just for the electric motor, but also for the onboard network.

The second big advantage of this system is the significant reduction of fuel consumption, comparative test runs showing that this technology is able to save about 15 percent fuel simply because the combustion engine is efficiently supported by the electric motor at precisely the right point. Such extra power in the acceleration phase thus not only helps the driver, but also serves to protect the environment and save money. The bottom line, therefore, is that BMW Group engineers, working on this research project, are opening up an enormous potential in improving not only the dynamic performance but also the environmental compatibility of the modern automobile.

12. Miniature Head-Up Display: Innovations in Formula One and Sailing.

- The latest and most advanced BMW technology from Silicon Valley.
- Efficient presentation of information while concentrating on the sport in full.
- Miniature display helping to save time and boost safety.
- Ideal for top-flight sport.

A highly advanced, innovative technology from BMW's Technology Office in Palo Alto, Silicon Valley, is revolutionising communication concepts in the world of sailing: A miniature head-up display in the sunglasses of the yachtsmen in the ORACLE BMW Racing Team allows visual presentation of a wide range of information, messages being presented directly in the user's line of vision. This helps to save valuable time and, in the process, ensures extra safety, the user being able to process visual information and concentrate in full on his job all in one.

Measuring just 6 x 8 millimeters, miniature head-up display comes with a high-resolution real-color presentation system based on active matrix liquid crystal display (AMLCD) technology. The key function of the display lies in a unique lens element, the so-called Free Form Prism (FFP) enabling the user to see superimposed images or alphanumeric information with optimum clarity.

The data presented in Ralf Schumacher's Formula One prototype helmet varies according to traffic conditions and the respective situation, for example by transmitting safety messages such as "oil in bend 2" or certain flag signals as well as emergency precautions. The miniature head-up display projects the appropriate "transparent" picture through the visor on the helmet to the front end of the car. Application of this miniature display technology in Formula One is no longer a technical challenge, so that now everything just depends on the rules and regulations applied by FIA, the World Motorsport Association.

Benefiting from the miniature head-up display in their sunglasses, the members of the ORACLE BMW Racing Team receive wireless racing information in real time, an on-board interface feeding data to the display through the telematrics system and tailoring the information in each case to the yachtsman's specific requirements.

This direct projection of information on the racing behavior of their ship allows the sailors to concentrate even more on their specific tasks and duties. And since, wearing their glasses, they are no longer required to focus on conventional instruments at various points on the yacht, they gain valuable time and are able to act and react quickly and efficiently.

This wireless system is designed to operate only on the sailing boat itself, both the rules and the limited range of the system as such making it impossible to transmit data from outside of the boat to the receivers in the sunglasses. Network-based innovation management serving the cause of technological progress.

The miniature head-up display was developed by the BMW Group's westernmost Research and Innovation Center Office right in the middle of Palo Alto in Silicon Valley, in close cooperation with BMW Designworks/USA. Since 1998, 16 highly qualified specialists - information experts, logistics engineers, chemists and various other engineers in numerous disciplines - have been working at the BMW Technology Office on one common objective: to develop the latest technologies as quickly as possible for mobile applications. "The Technology Office puts us right in the forefront of the latest developments, enabling us to use the fast pace of development in Silicon Valley, with cutting-edge communication and information technologies", states Dr. Burkhard Göschel, BMW Group Board Member for Development and Purchasing. In particular, the BMW Technology Office focuses on new technologies of a highly innovative nature.

13. BMW Motorsport: A Whole Series of Victories - to the Benefit of Series Production.

- The absolute benchmark: BMW's Formula One power unit.
- Technology transfer from the construction of innovative models
all the way to series production.
- Shifting gears and starting the engine in the BMW M3 just like Schumacher and Montoya.
- Touring car racing: pushing the BMW 3 Series to the extreme.

Millions of people the world over are able experience and enjoy BMW's success on the race track, with BMW winning outstanding events in international touring car racing, in long-distance and sport car races, and in Grands Prix. The World Championship in Formula One (1983) and Touring Car racing (1987), six European Championships in Formula 2, and no less than 17 European Touring Car Championships are just the tip of the iceberg made up of innumerable individual wins and national championships.

The foundation is strong and stable in all cases, BMW motorsport and BMW series development forming a strong team and both benefiting from their common efforts in many respects. Powerful synergies are being generated in all four disciplines of BMW motorsport in 2003 - Formula One, the European Touring Car Championship, the 24 Hours of Nürburgring, and Formula BMW talent promotion.

The Motorsport Division in Munich has access to all of the Company's technical resources at the Research and Innovation Center, to BMW Plants, in Design, Rapid Prototyping, Electronics or Production. Series development therefore benefits from motorsport, in particular from Formula One, serving as a high-tech research lab. For to win here you must really go all-out in every respect, completing the development to testing and racing cycle quickly and efficiently, without taking the slightest break in between.

The BMW Formula One power unit.
"P83" is the simple code-name of the power machine from Munich driving the BMW WilliamsF1 Team to success in the 2003 Formula One World Championship. This new engine once again outperforms its predecessor, the P82, which already set the benchmark in Monza in September 2002 revving at 19050 rpm and developing maximum output of almost 900 bhp.

The P83 weighs a lot less than 100 kilos and, even more importantly, has a low center of gravity. It is made up of some 5,000 individual components, 1,000 of which are quite different from one another, and is assembled on average in 80 hours. Each year more

than 200 F1 power units, including engines overhauled for testing and practice, leave the plant in the north of Munich.

Technology transfer from the construction of models all the way to production.
All core components of the F1 power unit are developed and produced by BMW - whether it is the cylinder head, crankcase, crankshaft or cam shaft, or the electronic engine management. In the words of BMW Motorsport Director Mario Theissen, "the transfer of know-how from motorsport to series production and back again was our mission and commitment right from the start in our Formula1 project."

To guarantee this transfer of technology between motorsport and series development and to achieve the highest level of efficiency in the process, BMW's F1 Plant operates right at BMW's main location in Munich, fully integrating the resources of the Research and Innovation Center only a stone's throw away. Benefiting from this support, BMW was able from the start to develop its own electronic F1 engine systems in-house, instead of having to call on renowned specialists from outside the company. Engineers otherwise working on the on-board electronics of the BMW M3 and M5, therefore, also created the electronic engine management for BMW's Formula1 power unit. And the knowledge they acquire in this process goes straight back into series production, the BMW 7 Series, for example, benefiting from high-performance processors developed, tried and tested in Formula One.

Shifting gears and starting the engine in the BMW M3 just like Schumacher and Montoya.
Other technologies carried over from Formula One are to be found in the cockpit of the BMW M3: the Sequential M Gearbox - SMG with DRIVELOGIC - and the Acceleration Assistant. The SMG drivetrain offers F1 transmission technology for everyday motoring, the driver shifting gears electronically by means of a paddle on the back of the steering wheel. Like in Formula One, an electrohydraulic system replaces the mechanical clutch engagement and gearshift process, enabling the SMG driver to keep his foot on the gas pedal while shifting gears. The Acceleration Assistant, in turn, is an automatic system ensuring optimum acceleration with controlled wheel slip comparable to Launch Control in Grand Prix racing cars starting from the grid.

Other examples of this technology transfer are perhaps less conspicuous.
In Landshut, for example, BMW has its own in-house F1 engine foundry affiliated directly to the regular foundry for series production engines to ensure a direct flow of new casting technologies and know-how to series production. And the same sand-casting process used for BMW's Formula One V10 therefore also serves to cast the oil sumps for the BMW M models as well as the intake system for BMW's 8-cylinder diesel engine.

Significant input also comes from materials research seeking to promote BMW's Formula One activities. Conversely, the F1 Team benefits from know-how and facilities in rapid prototyping, and BMW's own in-house Formula One components production shop affiliated, like the foundry, to their counterpart for series production vehicles also serves to connect the construction and production of motorsport and series products. Again in the words of Mario Theissen, BMW's Motorsport Director: "Making enormous efforts in Formula One developments, we are able to improve our own special in-house knowledge at BMW and transfer racing know-how to series production."

Putting the transmission to the ultimate test.
BMW's development and testing activities are by no means limited to the engine alone. On the contrary, the Company's resources also benefit the transmission and the drivetrain as a whole. "As a car maker we have the most advanced simulation and testing facilities otherwise simply not available to a racing team", says Theissen. "So we support Williams F1 in the design and calculation of transmission components and provide our test facilities for function and endurance tests. The range of options extends from the examination of individual components all the way to the simulation of complete races with a complete drivetrain."

Pushing the BMW 3 Series to the extreme.
In touring car racing BMW is looking at a lot more than just a complex drivetrain. For here the focus is on the entire car from A-Z, the 3 Series being the car to beat both in works trim and in the hands of many private drivers. Among the many activities pursued by BMW in this area, there is the German Touring Car Challenge with the four-door BMW 320i DTC featuring a two-liter six-cylinder power unit developing approximately 200 bhp and provided by BMW Motorsport to private drivers and for other, comparable racing series outside of Germany. This is the most series or production-like racing version of the BMW 3 Series.

The BMW 320i racing in the European Touring Car Championship is a lot more elaborate and sophisticated in its suspension and aerodynamic features, the two-liter straight-six developing some 260 bhp. This car is raced by three national teams, with support by BMW's National Sales Companies. And here, too, even this more demanding touring car based in its development and further improvement on the know-how and testing facilities of BMW's production engineers follows the clear principle that racing teams must be able to understand, handle and finance their car's technical features and qualities.

Another dimension yet again is the BMW M3 GTR, the winner of the American Le Mans Series (ALMS) in 2001 making its comeback in 2003 in the 24-Hours of Nürburgring. This is the most extreme M3 ever built in Munich, with its body a lot more muscular in its dimensions and overhangs than that of the regular M3 made partly of carbon fiber.

With its purebred racing suspension, this mighty coupe features a BMW V8 power unit developing more than 450 bhp instead of the usual 3.2-liter straight-six. A typical BMW M engine with its short stroke and high revs, the V8 is exactly the right power unit for the M3 GTR not only through its output, performance and driving qualities, but also on account of its compact shape and design. With the two rows of cylinders positioned at an angle of 90° and with the flat oil sump featuring dry sump lubrication, the engine fits snugly into the M3: Lengthwise, the four-liter V8 takes up two cylinders less space than the regular straight-six of the M3, providing enough room for a new cooling concept which offers not just thermal, but also aerodynamic benefits.

Formula BMW.

In the process of developing Formula BMW serving to promote, up-and-coming talents ever since 2001, another Division of the BMW Group also played a significant role: BMW Motorrad. The standardized monoposto racing cars starring in both the German Championship and in a special racing series in Asia feature 140 bhp four-stroke straight-four power units carried over from the BMW K 1200 RS motorcycle. In addition, Formula BMW sets the standard above all in safety technology, featuring an advanced carbon-fiber chassis to fulfil the safety requirements made of far more powerful Formula 3 racing cars and even exceeding the usual standards in Formula One through developments such as the BMW Formula Rescue Seat (FORS). The crash tests required to substantiate these qualities are carried out in BMW's crash facilities in Munich.

14. A Heritage of Innovation.

- BMW paving the way in automotive electronics.
- First-ever xenon headlights and head airbags in series production.
- BMW introduces the first anti-lock brake system (ABS) and catalyst technology for motorcycles.
- First series production cars with natural gas drive, first fleet of research cars with hydrogen drive - all from BMW.
- World-first introduction of emission-free clear powder paint in production.
- Leading position provided by the first fully variable valve drive and the first six-speed automatic transmission.

The BMW Group looks back at a heritage of almost nine decades in the world of motoring. The success of the Company is based, first, on the appeal and quality of truly outstanding products and, second, on the courage to enter new terrain with innovative technologies and turn visions into reality. For at the end of the day only companies standing out from the competition through their innovative power will be really successful in the long run.

Whilst aircraft engines played the leading role with BMW in the first years of the Company after 1916, BMW entered road transport in 1923 with the introduction of the first BMW motorcycle, the R32. Six years later BMW car production started in Eisenach with a licence version of the Austin Seven, the BMW 3/15 commonly referred to as the BMW Dixi. Apart from a rapidly growing model range, BMW also hit the headlines through world records in aviation as well as a long series of success on two and four wheels in international motorsport.

World debut in post-war Germany.
In the post-war years with the primary focus on the reconstruction of the country, a large BMW saloon made its debut at the 1951 Frankfurt Motor Show: the BMW 501. Starting in 1954, the world's first light-alloy V8 power unit displacing 2.6 liters and developing maximum output of 100 bhp made its entry into the market in this classic later gaining fame as the "Baroque Angel".

Reaching the late '70s, electronics made their way into the automobile world -and BMW immediately took over the position of the electronics pioneer in the industry, introducing numerous innovations for the first time. The electronic speedometer, for example, made its debut in 1977 in the first-generation BMW 7 Series, followed by the fuel consumption indicator and BMW Check/Control entering the market in 1981 in the 525i and 528i.

Following the 3 Series already available as of 1983 with run-flat tires featured as an option, the second generation of the BMW 7 Series in 1986 introduced a wide range of innovations now state-of-the-art also in other model series further down the line: ellipsoid headlights with automatic headlight range control, Digital Motor Electronics with a defect memory, as well as windscreen wipers with speed-related intermittent wipe.
Innovations on two wheels.

BMW has also made a great name for itself as a pacemaker for new technologies in the motorcycle market. Following the BMW R 90 S introduced in 1973 as the first series model with double disc brakes, the K 100 entered the market in 1983 with the world's first all-electronic ignition not requiring a distributor. The Paralever system enhancing rear wheel suspension was presented in 1987 for the first time on the R 100 GS, with the K 100 introduced in spring 1988 making BMW the first motorcycle manufacturer in the world to offer an electrohydraulic anti-lock brake system (ABS).

In the very same year the top-of-the-range BMW K 1 introduced the first electronic engine management for an optimum combination of output, dynamic performance and fuel consumption, and ever since 1993 the patented BMW Telelever system for the front wheel has made yet another significant contribution in enhancing active safety on two wheels.

BMW is also fully aware of its responsibility for the environment: In 1991 BMW became the first manufacturer in the world to feature a fully controlled three-way catalytic converter for the motorcycle, and launching the C1 in the year 2000 BMW presented an unprecedented safety concept for mobility on two wheels. Indeed, the C1 is so safe that it qualifies as the first motorcycle ever the rider is allowed to use without a helmet.

In 1988 the M3 became the first car to feature an intake manifold adjustable in two stages for even more powerful torque at low engine speeds. And in engine production technology BMW introduced cracked connecting rods for the first time in 1993, the two sections of the connecting rod bearing not being cut open, but rather broken at a predetermined point in the machining process and thus ensuring a much more precise re-fit of the two fully machined sections in subsequent assembly.

Another particular area to which BMW has always given great significance is safety: Introducing xenon headlights in the 7 Series in 1991, BMW once again pointed a bright light into the future leading to the introduction of the front passenger airbag with seat occupancy detection in 1994 as another BMW first, the life-saving airbag only being activated when actually needed.
In 1997 the ITS head airbag made its debut in the 7 Series, this tubular structure stretching across the side window and keeping the occupant safely inside the car in a

collision from the side whilst at the same time protecting him from objects intruding from outside. Two years later the 7 Series became the first car to offer head airbags also for the passengers at the rear.

Sustained, ongoing progress.
Building the first production cars with dual-mode natural gas drive in 1994, the BMW Group once again paved the way for mobility compatible with the environment, the BMW 316g and 518g being able to run on both natural gas and gasoline. Natural gas drive generates far less carbon dioxide harmful to the earth's climate than engines running exclusively on gasoline or diesel alone.

Through its CleanEnergy project, the BMW Group seeks to win over worldwide public support of hydrogen, the ideal fuel for mobility in future.
On the occasion of the Expo 2000 World Fair, the BMW Group, running the first small series of 15 BMW 750hLs with hydrogen drive, clearly demonstrated the practical qualities of the combustion engine in conjunction with this source of energy so compatible with the environment, thus consistently paving the way for sustained mobility.
Production technology is yet another area where the BMW Group sets new standards time and again. Apart from the changeover of all production plants one after the other to water-based paint, the introduction of zero-emission clear powder paint application at the Dingolfing Plant in 1996 has already set a new benchmark.

Undaunted innovative power.
In 1997 BMW presented a windscreen on the 8 Series Coupe featuring a dirt- and water-repellent surface coating. Another world debut was the introduction of water-cooled alternators on the V8 and V12 power units.

Introducing the fourth generation of the 7 Series in 2001, BMW launched a genuine cavalcade of innovations, with world debuts such as the one-hand-operation iDrive control concept, the electronically controlled parking brake, the Brake Force Display, the infinitely variable intake manifold, as well as the world's first six-speed automatic transmission in a production car. Fully variable VALVETRONIC valve management presented for the first time in the BMW 316ti Compact in the same year, in turn, is a truly revolutionary system in engine technology, infinite adjustment of valve lift and opening angles allowing both the gasoline and the diesel engine to run without a throttle butterfly, enhancing fuel economy significantly in the process.

BMW Group in America

BMW of America has been present in the United States since 1975. Since then, the BMW Group in the United States has grown to include marketing, sales and financial service organizations for the BMW and MINI brands and Rolls-Royce Motor Cars; DesignworksUSA, an industrial design firm in California; a technology office in Silicon Valley and various other operations throughout the country. BMW Manufacturing Corp. in South Carolina is part of BMW Group's global manufacturing network and is the exclusive manufacturing plant for all Z4 roadster and X5 Sports Activity Vehicles. The BMW Group sales organization is represented in the U.S. through networks of 340 BMW car, 327 BMW Sports Activity Vehicle, 148 BMW Motorcycle retailers, and 70 MINI dealers. BMW (US) Holding Corp., the BMW Group's sales headquarters for North, Central and South America, is located in Woodcliff Lake, New Jersey.

Information about BMW Group products is available to consumers via the Internet at http://www.bmwusa.com http://www.bmwmotorradusa.com and http://www.miniusa.com

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Journalist note: Information about the BMW Group and its products is available to journalists on-line at the BMW Group PressClub at the following address - www.press.bmwgroup.com.

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