

FROM THE VERY OUTSET, BMW HAS SET MILESTONES IN LIGHTWEIGHT

LOSING WEIGHT FOR MORE PLEASURE

One essential design principle of BMW's current EfficientDynamics strategy is lightweight construction. A look at BMW's history shows how consistent the use of innovative and light materials has always been to this day. Even the company's very first product featured weight-saving materials.



← LEFT: Competence in the very outset: precision grinding of light cast parts in the World War I era in the Pilot Works

By Niklas Drechsler, Max Bauer Photos BMW AG

"F = m x a". As early as the 17th century, Sir Isaac Newton's famous formula already defined that dynamics can be improved by either increasing driving force or by decreasing mass. True to this principle, BMW has, from the very beginning, combined the consistent enhancement of their drive units with the reduction of weight. BMW refers to the combination of using innovative materials and creating

clever designs as "intelligent lightweight construction". It is the recurrent theme that runs through decades of BMW's history as well as through the company's various fields of activity.

From a very early stage, BMW took into account that weight reduction not only boosts a vehicle's performance and dynamics (by increasing the speed and decreasing the braking distances) but

also lowers its fuel consumption. Today this plays a more important role than ever before. It also helped the company in its early years to achieve decisive advantages over its competitors both in aircraft engine production and motor sports.

The Bavarian Motor Works' first products were engines. From the very begin-

S IN LIGHTWEIGHT CONSTRUCTION AGAIN AND AGAIN

FOR MORE DRIVING



↑ ABOVE The body frame of the BMW 328 racing saloon of 1940 boasted a mere 32 kg of weight.

Magnesium CRP (carbon-fibre-reinforced plastic)

ning, it seemed reasonable to reduce the weight of drive elements – cylinder heads, pistons, engine blocks – by using aluminium, magnesium, and other light materials. This skill was continuously improved, later adopted for the design of the complete chassis, and has always been employed in mass-production and in motor sports. When BMW started to manufacture a new generation of automobiles in

the 1930s, they started to reduce the weight of the bodywork and trim parts as well, beginning with innovative design ideas, as was the case for the chassis frame of the BMW 303, and soon following with light materials also.

During recent decades, many BMW products have featured measures for weight reduction. Here we want to

present to you some special lightweight construction highlights from BMW's history of more than 90 years:

BMW's very first product, the aircraft engine IIIa of 1917, weighed just 287 kilograms. It was considerably lighter and more efficient than competing products. The main weight-saving measure was the use of aluminium pistons.

Aluminium

Acrylic glass



← LEFT The chassis frame of the BMW 303 led the way for other manufacturers.

In 1923 BMW started to manufacture motorcycles. One year later it launched the R 37, the world's first motorcycle to have an engine with cylinder heads made of light metal. As early as 1926, BMW presented a V12 cylinder aircraft engine that not only featured aluminium pistons but also an engine block made of magnesium. With a continuous output of 585 hp and a weight of only 510 kg the engine achieved a remarkable power-to-weight-ratio of 1.15 hp/kg.

When it came to automobile design, BMW engineers also dedicated themselves to lightweight construction at an early stage. The purchase of the vehicle factory Eisenach in 1928 made BMW an automobile manufacturer. Only five years later the company was already able to present a vehicle featuring lightweight construction elements: the BMW 303.

From then on, BMW engineers systematically incorporated the advantages of lightweight construction into the mass-production of automobiles.

To reduce the weight of the chassis frame of the BMW 303, the tubes were built with larger cross-sections in places exposed to high forces and much smaller cross-sections where no or lower forces act upon the frame.

BMW had this construction patented in 1933. It went on to be adopted by many other automobile manufacturers.

With the launch of the BMW 132 in 1934, BMW fielded another aircraft engine with lightweight construction as an integral design characteristic. The radial engine had air-cooling, which saved the weight of an elaborate liquid-cooling system. With a continuous output of 690 hp and a weight of only 525 kg, the engine

boasted an excellent power-to-weight-ratio of 0.76 hp/kg.

In the middle of the 1930s, BMW built the motorcycle type 255. Thanks to lightweight construction it became one of the most successful racing motorcycles of the pre-war period. Except for the aluminium cylinder heads, all cast parts were made of magnesium. Parts of the handlebar, the telescopic fork, the wheel hubs, and the rims were made of aluminium or aluminium-based alloys. Despite featuring supercharger and cardan shaft drive, the racer only brought 140 kg to the scales; this made it 22.5% lighter than the series production version and about 15 kg lighter than competing products.

The series version of the BMW 328, BMW's most important sports car of the pre-war period, not only had a weight-saving chassis frame but also body parts



↖ ABOVE LEFT Successful in motor sports: Rudi Reich on a BMW R 37 with light metal cylinder heads.

↑ ABOVE The BMW 700 RS was specifically developed for hill climbs. It features a sophisticated tubular space frame with an extremely light slider bodywork made of aluminium.

made of aluminium. The racing versions of the BMW 328 were even more consistently trimmed for lightweight construction. Both the BMW 328 Touring Coupé, the winning vehicle at the Mille Miglia 1940, and the BMW 328 Kamm racing saloon featured bodies with lightweight tubular space frames. The frame, weighing just 32 kg, featured an outer skin made of aluminium. For this reason these vehicles boasted an overall weight of just 760 kg.

After World War II, BMW continued to set benchmarks in lightweight construction. The V8 engine, available from 1954, was the first V8 series engine to have both the engine block and the cylinder head made of light metal. It was a major contributor to turning the BMW 507 into a sports car.

The first complete BMW to be based on extremely consistent lightweight construction after

the war was the BMW 700 RS. The racing car, launched in 1961, featured a tubular space frame and an outer skin made of aluminium; it weighed in at just 630 kg. Thanks to this low weight, Hans Stuck needed no more than a 2-cylinder flat twin engine with 80 hp to win hill climbs.

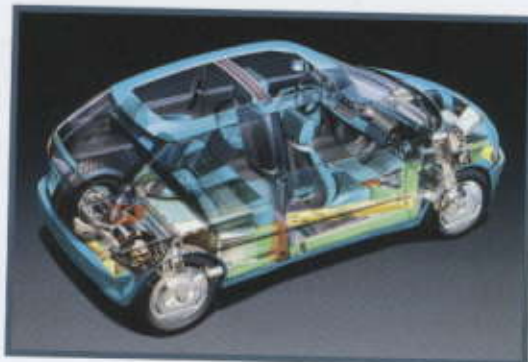
In the early 1970s BMW set another milestone in lightweight construction with the BMW 3.0 CSL. By using aluminium hoods and doors and acrylic glass windows, as well as omitting insulating materials, the engineers managed to save more than 200kg compared to the BMW 3.0 CSi. In the end, the vehicle brought a mere 1,165 kg to the scales. Weight reduction also played an important role in designing the BMW Z1 in 1988. The roadster was based on a self-supporting monocoque construction made of hot-dip galvanized steel profiles; it had doors, covers, bumpers, and hoods made of synthetic

↓ BELOW Air-cooling instead of water-cooling: the radial engine BMW 132 (1934).

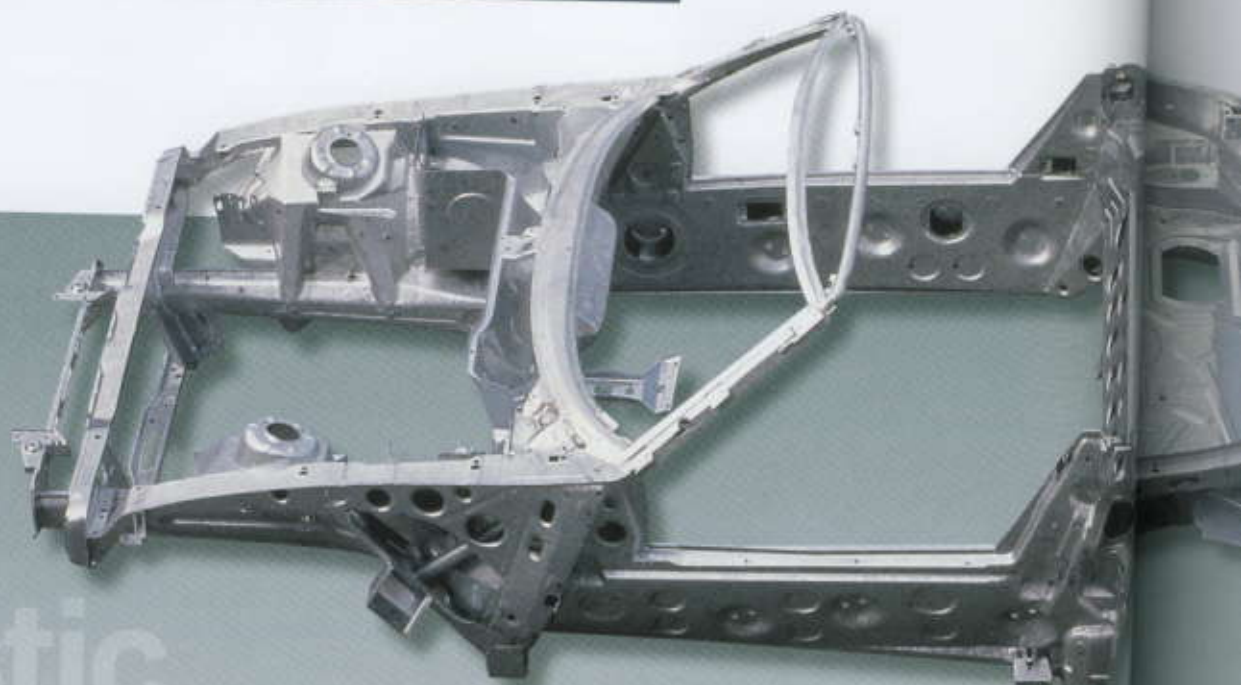
INTELLIGENT LIGHTWEIGHT CONSTRUCTION

The simplest way to reduce a vehicle's weight is to omit extra equipment and luxury features, like a sun-roof for example. Lightweight construction, however, means that certain components are made of lighter materials, such as windcreens made of thin or acrylic glass. At the same time it is a never-ending search for construction designs that are intrinsically lighter while still meeting all safety and quality requirements. Component parts exposed to high and constant strain are reinforced, while weight is saved in less critical places. BMW Group refers to this concept as "intelligent lightweight construction".





- ← FAR LEFT The omission of comfort features and the use of new lighter materials made the BMW M3 CSL a real street racer.
- ← LEFT The prototype BMW E1 saved weight with an intelligent body-work structure.



Plastic

Paper honeycombs



PIONEERING ROLE IN CASTING TECHNOLOGY

To process the materials required for lightweight construction in a professional way, BMW became experts in casting light metals very early on. To this day, this expertise is one of the company's distinctive characteristics. Today BMW has a special department that is committed exclusively to the development and the use of innovative materials and manufacturing methods in the field of light metal casting and synthetic materials – the Innovation and Technology Center for Lightweight Construction (LITZ) in Landshut. The LITZ has already developed numerous innovations: for example, BMW Group is today's only automobile manufacturer worldwide to produce crankcases made of aluminium magnesium compounds. The experts in Landshut have also managed to manufacture carbon-fibre-reinforced plastic into a structural component in a highly automated and economic manufacturing process.

material. With a weight of 1,250 kg it is not only relatively light, but it also increased driving pleasure, thanks to optimum weight distribution and a low centre of gravity.

Three years later, BMW launched the world's first thoroughbred and fully-fledged electric vehicle: the BMW E1. The four-seater was not only fully-fledged because it was designed as an electric vehicle from the outset, but also because the design was consistently based on lightweight construction. Its body, weighing just 900 kg, was manufactured from extruded aluminium sheaths and combined with an outer skin made of synthetic materials and aluminium, thus compensating for the heavy, high-energy sodium-sulphur battery that weighed 200 kg.

In the middle of the 1990s, BMW managed to save a considerable amount of weight in large-scale production for the first time. The fourth generation BMW 5 Series had a chassis manufactured entirely from light metal, saving about 30% of the overall weight. The use of full aluminium engines saved another 30 kg. Despite featuring additional special equipment, this BMW 5 Series was considerably lighter than its predecessor. Lightweight



THE IDEAL MATERIAL FOR EVERY PART

Today, steel is still the most frequently used material in vehicle construction, but in constantly decreasing amounts. As early as 1917, BMW began using aluminium in aircraft engine production – a light metal that is about one third lighter than steel. To this day aluminium is, however, only used for certain parts, as it is rather expensive, difficult to process, and does not exhibit the same rigidity as steel. Throughout the years, more and more components made of fibre compound or synthetic materials have been used in addition to light metals. For example, in 1971 windscreens made of acrylic glass were built into the BMW 3.0 CSL as a weight-saving measure.

Today the use of carbon-fibre-reinforced plastic (CRP), as employed in the BMW M3 CSL, in the current BMW M6, and in the BMW M3, as well as the use of materials adopted from air and space technology have become second nature to BMW. The advantages of synthetic materials are that they have a lower self-weight, are easier to process, yet exhibit a high rigidity. Magnesium, which BMW already employed in aircraft engines in the middle of the 1920s, is also expected to have a promising future. It exists in large quantities, is about 30 % lighter than aluminium, and almost 80 % lighter than steel. Today, BMW counts on an intelligent mixture of different materials.



FIGURE The monocoque chassis of the BMW Z1 is made from aluminium.

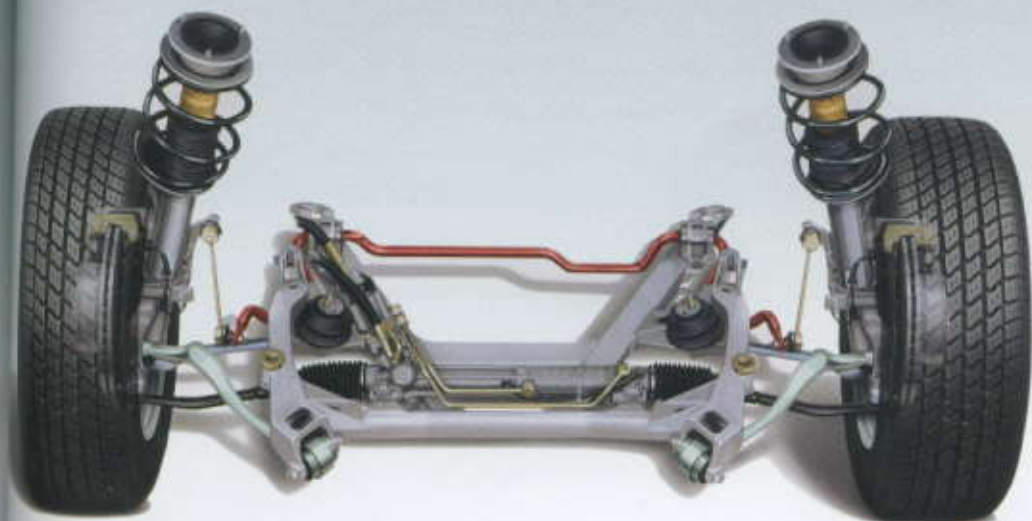
construction was also continued in the current generation BMW 5 Series. As the body shell was made of a composite structure, the vehicle's weight could be reduced by a further 75 kg compared to the previous model, despite featuring an increased range of equipment. The vehicle front, for example, consisted of a weight-reduced aluminium front (called "GRAV", "GewichtsReduzierter Aluminium-Vorderbau"). The BMW 6 Series benefited from these measures as well.

A recent example of very consistent lightweight construction is the BMW M3 CSL of 2003, which was even christened after it – CSL stands for Coupé Sports Lightweight construction. In addition to the roof, which is 6 kg lighter than the M3 steel roof, the front bumper brackets, the front apron, and the rear diffuser were also made of carbon-fibre-reinforced plastic. Further-

more, it featured a rear window made from thin glass, a paper honeycomb sandwich plate for the luggage compartment floor, continuous filament thermoplastic for the support structure of the through-load facility and rear bumper brackets, and lighter seats. Despite boasting a powerful 360 hp high-performance engine, it brought a weight of only 1,385 kg to the scales.

In view of the strict legal requirements regarding CO₂ emission, BMW's experience and skills in lightweight construction provide the company with an important technological advantage. The primary goal of all measures is to optimize driving pleasure: the distinguishing feature of all BMW products.

AA



← LEFT The front axle of the lightweight chassis from the fourth generation BMW 5 Series.

WINDSHIELD MADE OF WEIGHT-SAVING,
DOUBLE-LAYERED SAFETY GLASS

FRONT AND TRUNK HOODS
MADE OF ALUMINUM

LIGHTER BATTERY

NO BUMPER

WEIGHT-SAVING SPORTS LOCKING
OF THE FRONT HOOD

BMW 3.0 CSL (COUPE SPORT LIGHTWEIGHT CONSTRUCTION)

Its name says it all. Launched in 1971, the lightweight-construction variant of the big 3.0 litre coupes, at a mere 1,165 kg, is more than 200 kg lighter than the 3.0 CS and the 3.0 CSI. Optional comfort features were excluded from the design, which was based on light materials. At the same time, the engine output was boosted in two steps. The outcome was improved driving dynamics and increased efficiency. As a racing coupé boasting these optimized features, it dominated the Touring Car Championships and managed to pocket six European Champion titles.

The BMW 3.0 CSL has made a significant contribution to answering the question of where and how to save weight. Its recent namesake, the BMW M3 CSL of 2003, has, for example, been directly influenced by it.

TECHNICAL FACTS

1971-72: 2,985 cc, 132 kW/180 hp,
169 units

1972-73: 3,003 cc, 147 kW/200 hp,
929 units

1973-75: 3,153 cc, 151 kW/206 hp,
167 units

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SYNTHETIC MATERIAL

LIGHTER FLOOR CARPETS

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