Mazda2 R&D files

Targets:

• Design:	dynamic & refined	☑
• Body:	lightweight and compact	☑
• Driving dynamics:	enjoyment in city and on road	☑

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A word from Shigeo Mizuno, New Mazda2 Programme Manager

The Mazda2 from the Perspective of an Engine Specialist

„I've been involved with engine development since I joined Mazda in 1985. With the previous Mazda2, which we launched in 2002, I was responsible for the powertrain. But with the new, third generation Mazda2, I found myself overseeing every part of the car in the role of Programme Manager.

After two decades of viewing cars from the perspective of an engine specialist, I can say with pride that the Mazda2 has always had some of the best-performing engines in the class. But the concept behind the first (Demio, 1997) and second generation (Mazda2, 2002) models was to deliver the best possible space in a B-car, so the resulting weight of the body was a handicap for engine performance. It has significant influence on three fundamental areas : running, turning and stopping. This in turn impacted fuel economy, cost-effectiveness and environmental compatibility.

When I became Programme Manager for the new generation Mazda2, I was determined to realize the Zoom-Zoom driving pleasure that has become a Mazda hallmark and to achieve superior fuel economy, so the development

issue to which I devoted the most effort as a way to realize the new product concept was weight reduction.

Weight-Saving Technologies with Astonishing Benefits

The new B-car weight-saving technologies that emerged from the advanced development project fall in two main areas: (1) a body structure in which a new kind of framework and high tensile steel are employed in line with a new crush concept; and (2) hysteresis-minimizing measures whereby spot welds and weld bonds are used to stiffen highly stressed body parts, not the body as a whole.

Pursuing a Global B-Car Standard

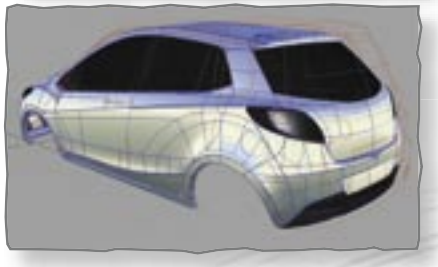
To create a B-car global standard, I envisaged a car with (1) a distinctive design that would appeal to people all over the world; (2) the superior driving performance that people expect of Mazda; and (3) the fuel economy that's expected of a B-car. My approach to realizing such a car was based on weight savings and downsizing. I decided to make the body smaller than that of the previous generation Mazda2 in line with the needs of target customers, and I decided to apply design techniques that would make the body look even smaller and leaner than its numerical dimensions would suggest. In other words, I targeted a huge change of identity from the utility-oriented large hatchback that's represented by the second-generation Mazda2 to a more personal, smarter-looking B-car.

The new Mazda2 encapsulates everything my development team wanted to achieve. I'm proud to be able to describe it as a new global B-car standard. This exciting new product is certain to attract new Mazda fans and strengthen our brand presence around the world."

Design

A Condensed Form of Dynamism

The all-new Mazda2 is going back to the most fundamental form for a B-car: a small hatchback. Really compact like a B-car should be, the Mazda2 goes against the trends being shorter than its previous generation.



Dimensions		New Mazda2	Previous Mazda2	Difference
Overall Length	(mm)	3,885	3,925	-40
Overall width	(mm)	1,695	1,680	+15
Overall height	(mm)	1,475	1,530	-55
Wheelbase	(mm)	2,490	2,490	=

Final Design Choice in the Streets of Milan

Ikuo Maeda, chief designer of the new Mazda2, explains how the final decision out of the last two proposals of the car's design was made in Europe: "I was on a business trip to Milan in 2005, I received a phone call from a senior manager in Japan: 'You make the choice.' Now I was really on the spot! I spent a week walking around Milan, mentally placing the two design proposals in all kinds of scenery. Only then was I able to make the final choice."

Short, but Strong

The final challenge for the design team was to refine the selected design model for the production vehicle by trimming away superfluous element. To make the body look optimally compact, the team worked with engineers in charge of collision safety, comfort, ease of ingress and egress.

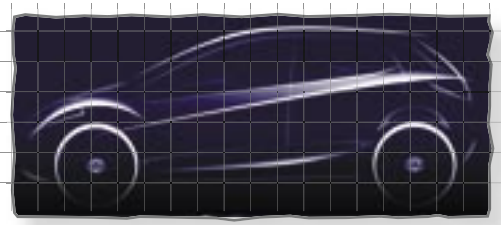
Movement even when Standing Still

To express the next-generation Mazda design identity, the design team evolved the athleticism that forms the Mazda design DNA in pursuit of bold and diverse expressions of movement. Even a brief glance at the new Mazda2 is enough to create lasting mental impressions of its wedge shape (this conveys a strong sense of forward motion) and of its highly sculpted contours (these are exemplified by pronounced narrowing fore and aft of the A-pillars).

Sassou: a foretaste of the new Mazda2

Peter Birtwhistle, Chief designer of Mazda Europe design center (Oberursel, Germany): "The Sassou concept proposed the vision of a possible future Mazda B-car at the Frankfurt Motorshow 2005. The concept was aimed at urban singles who commute on a daily basis, with a lightweight and aerodynamic exterior look and a flexible, high-tech and interactive interior. One of the key request from Hiroshima to the Frankfurt design team, was for us to develop a body design that would path the way for the launch of the new Mazda2. If you look at the Sassou body, you can quickly recognize the strong front fender lines and rising body crease that are also dominant on the new Mazda2. The graphic form of the side glass is also similar to the production car and the arrow formed headlamp indicators of the Mazda2 are also a subtle link to the striking form of the Sassou front lamps."

Design



Rhythmical visual movement

The energy exuded by the body form is characterized by rhythmical visual movement between the surfaces and lines. A distinctive character line that links the front fender arch to the body shoulder on each side is a key feature. Other character lines on each side of the body create further visual movement. One line begins on the front bumper and continues as a line that runs around the periphery of the headlamp housing. One line begins as the curvature of the position lamp in the headlamp housing and continues as a curve on the front fender. And the door shoulder line extends all the way to the periphery of the rear lamp housing. Each line gently fades at each end, helping to combine compactness with a sense of speed and rhythm.

Prominent Fenders, Mazda design cues

A strong sense of stability underpins the expressions of movement of the new Mazda2. To realize this, the designers maximally emphasized the wheel areas partly by means of boldly shaped front fenders that are reminiscent of the Mazda RX-8/Mazda CX-7 and partly by means of ample contours in the rear fenders and nearby surfaces.

Sports Appearance Package*

The Sports Appearance Package features different shapes for the front bumper and grille and adds side skirts and a rear spoiler. With the standard version, the front overhang is short to emphasize the body's compactness. With the Sports Appearance Package, the front bumper is more generously proportioned and is lower at the bottom. Combined with the side skirts, it creates a lower visual centre of gravity and a strong impression of stability.

* According to markets

Interior Design Theme: "A Space that Communicates Movement"

The instrument panel's left- and right-hand portions, where there are no controls, curve forward (away from occupants), emphasizing the effect of perspective. The position and shape of the A-pillars combine with an extremely low belt line (the front end of the belt line is 40mm lower than the front end of the belt line on the previous Mazda2) to enable excellent forward visibility. These innovations create an impression of airiness and space and reduce any perception of a cramped cabin.

Lightweight

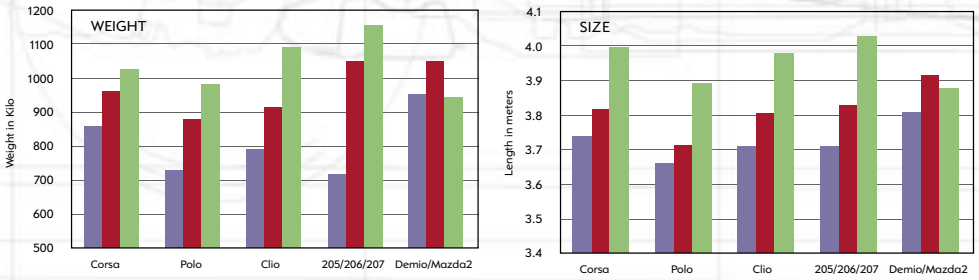
B-segment in Europe : customer expectations

Extensive Mazda research highlighted the Top10 priorities that many customers take into consideration when buying a B-car: clearly fuel consumption (and all financial related matters), style and size are among the most important criteria to take the decision. Mazda's assignment in developing the new Mazda2 was to fulfil the highest B-segment customer expectations.

1 Price/Financial Considerations (incl. Fuel Consumption)
2 Design (Incl. Ergonomics)
3 Size (incl. Dimensions, roominess, package)
4 Driving Characteristics
5 Quality Related Aspects
6 The Dealer
7 Specification/Accessories
8 Technical Aspects
9 Comfort
10 Safety/Security

A clear trend in the automotive industry over the last decades has been to increase both weight and dimensions from one generation of product to the next.

Evolution through three generations



Source: Mazda Study (2007)

Lightweight: a tradition at Mazda and a statement for the future

In March 2007, Mazda President and CEO, Hisakazu Imaki has announced its new, four-year mid-term plan, the Mazda Advancement Plan (MAP). The presentation highlighted Mazda´s desire to develope safe, lightweight new generation platforms able to offer excellent dynamics. Weight-saving efforts are seen as motivating challenges by the Mazda R&D teams. Mazda2 is one of several programs were weight was regarded as "THE" key enemy.
The Mazda MX-5, icon roadster is the perfect example of what is called the "gram strategy". Basically every single component has been studied with the aim of reducing its weight in keeping its function and safety standard unaltered. Even the smallest detail like the rearview mirror's design saved 84 grams. The result of this strategy can be seen in the 3rd generation MX-5, being bigger in dimensions and offering more equipments, it is only 10 kg heavier than its predecessor.

New Steels:

HTS (high-tensile steel), VHTS (very-high-tensile steel), UHTS (ultra-high-tensile steel)
The rigidity of steel is indicated in Newton per mm2 (N/mm2) or in Mega Pascal (Mpa). A normal steel secure a rigidity level between 100 to 250 Mpa. HTS which appears a few years ago have a rigidity of 300 to 500 Mpa.
Newly introduced, UHTS offer rigidity beyond 800 Mpa. The evolution on steels have greatly contributed to increase the safety level.

Steel type	New Mazda2 (in mass ratio)
440 Mpa	10%
590 Mpa	31%
780 Mpa	9%
980 Mpa	3%

Weight-Saving Measures on the new Mazda2

Body Shell

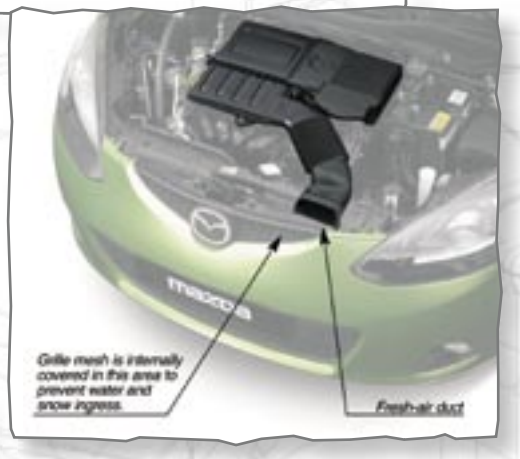
Smaller dimensions alone would have lowered the weight of the body shell by four kg, to 233 kg. Measures needed to increase rigidity and crash resistance would have then raised it up to 244 kg. But thanks to an optimised body structure, weight was reduced to 215 kg, 22 kg less than the old Mazda2.

Exhaust System

Mazda eliminated the underfoot catalyst, and for the 1.3-litre petrol model, the presilencer used in the Mazda2 until now was also eliminated.

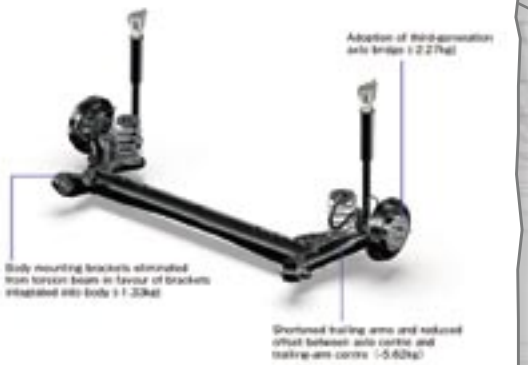
Intake and Cooling Systems

For the intake system, Mazda engineers moved the fresh air inlet from its original position behind the left headlamp to the top of the radiator shroud. This new position removed the need for the resonator and baffle.



■Weight-saving measures in front suspension

■Weight-saving measures in rear suspension



Suspension

Mazda weight specialists were able to save an impressive 13 kg using weight optimising measures in the suspension. These included making the trailing arm on the rear axle shorter and giving the front lower arms an open-section structure. This reduction in unsprung weight means both better handling and ride comfort.

High-tensile steel

The use of high and ultra-high tensile steel alone saved 22 kg. The 980 MPa-grade steel used in the area of the B-pillar is a kind of central beam for the passenger cell. Strengthened joint reinforcements in the doors and liftgate saved six kg, without having to use thicker material.

Door-Mounted Speakers

Mazda's weight watchers were also at work with the door-mounted speakers. By changing the magnets from a ferrite type to neodymium, and making the plastic moulding single-piece, a total weight savings of 0.98 kg was achieved.

Bonnet

With a smaller striker assembly and thinner hinges, the bonnet saved 0.69 kg.

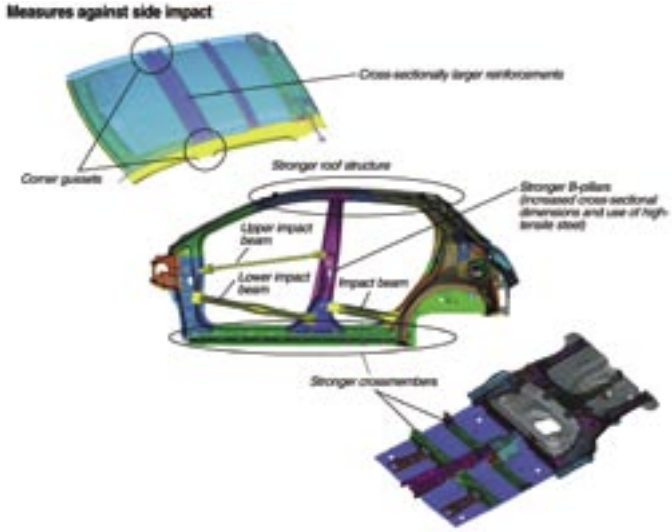
Electrical System

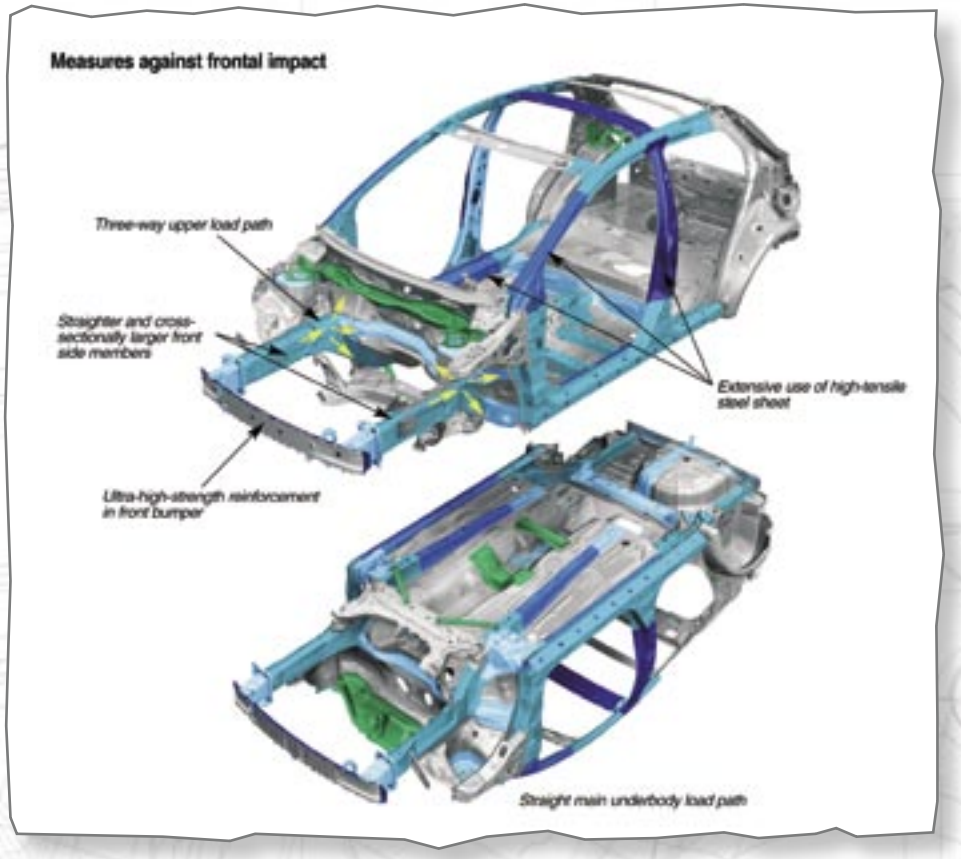
A shorter wiring harness saved a total of 2.86 kg – achieved by an insightful placement of large units and power-supply parts.

Safety

Lightweight construction doesn't mean compromise on safety....

The natural industry trend is to offer safer, better equipped and fuel efficient cars, weight management therefore becomes one of the toughest challenges facing R&D. One of the solutions used by Mazda is aluminium, to be found in our sportscar products (chassis, powertrain and body parts for the MX-5 and RX-8). However, the application of aluminium for a large-scale sub-compact can't ensure a price performance in line with customer expectations, therefore Mazda decided to use a broader range of special steels. Among them are HTS (high-tensile Steel), VHTS (very-high-tensile steel) and UHTS (ultra-high-tensile steel). UHTS is used in areas where deformation should be reduced such as B-pillar. These steels offer for the same weight far higher rigidity levels, used in thinner sheet for some parts of the bodyshell, they help to reduce the overall weight.





Internal Mazda crash test session

Driving dynamics: testings, testings, testings... in Hiroshima

Lightweight testings

The lightweight technology project began based on a previous Mazda2 prototype. It was a laboratory test vehicle as for any advanced technology developments and helped to validate the choices.

Performance feel

Many sound source detection systems have been installed in and out of the car to explore and validate noise levels.

Ergonomics testings

The drive and performance feel has been studied for all kind of passengers. Here, Keiko Ito-san (1.50m tall) was involved in the ergonomic testings and the validation of pedal pressure when wearing various kind of shoes, including high-heeled shoes. The pedal stroke has been optimized for a brisk of sporty feel.

Winter testings

At the Mazda Kenbuchi Proving Ground, the R&D team conducts annual cold testings. Test vehicles are left with melted snow on the body and underbody after driving to evaluate durability (esp. door rubbers) and driving performance. Any snow or ice related damage is being investigated. The in-board picture is related to ABS/DSC cold testings.

Prototype vehicle production

The prototype production is very different from that used for mass production vehicles. They are produced by hand with the chassis shaped by molds and hammers instead of a sheet metal press.

Additional components are again assembled by hand.

Prototype shipping

The new Mazda2 prototype is packed carefully, placed in its tailored steel container, ready to be shipped to Europe for more testings... Goodbye Hiroshima!

Driving dynamics: testings, testings, testings... in Europe

Many months before its World Premiere in Geneva, the new Mazda2 came in Europe to undergo a comprehensive test program. Based in Oberursel, near Frankfurt, the Mazda European Research and Development Center (MRE) is ideally located to replicate all kinds of driving conditions from demanding curvy roads to unlimited speed Autobahns.

The 1.3 engine is offered with two power outputs. Therefore, many tests have been conducted to optimize engine performance.

Typical at Mazda is the multi-cultural cooperation between Japanese and European R&D staff. During these road testings, 18 engineers have been working together to finalize the European settings. Here, Michael Ruppert from the European Chassis Team listening to Toshiaki Aoki.

An important part of the European responsibilities has been to confirm the tyre choice. Mazda2 should offer excellent road holding, always exciting to drive, with as primary target a very low fuel economy. All the different tyres have been tested and approved against extensive European driving conditions.

Germany offers a broad spectrum of conditions for vehicle testings in Europe. Stability at high speed was part of the program.

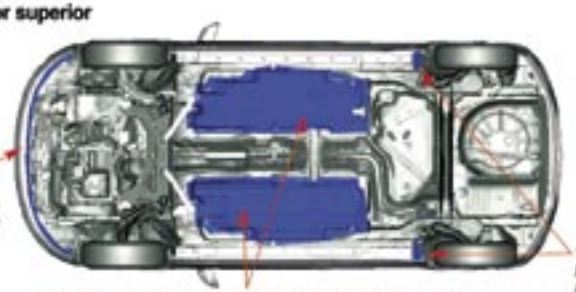
A real "souvenir" picture for the Hiroshima engineers: the road leading to the famous "Nordschleife" in Nürburg.

All Mazda prototypes as well as some models of the competition have been evaluated.
Static, functional and dynamic evaluations are part of the session.

Fuel economy: one of the best in the category

Besides the lightweight construction of the new Mazda2, additional measures contribute as help to reduce the fuel consumption.

Underfloor parts for superior aerodynamics



The front airdam skirt limits turbulence near the front wheels and front floor.

The centre floor undercovers limit turbulence in the airflow under the floor and along the sides of the body (certain markets only).

The rear tyre deflectors limit turbulence in the airflow around the rear wheels and along the sides of the body.

Aerodynamics

With a Cd of 0.31 and a front projected area of 2.11 m2, the new Mazda2's superior aerodynamic efficiency greatly contributes to fuel economy at high speeds. It also yields significantly lower wind noise.

Shape improvements in the body

The rear edge of the liftgate's topmost surface is angled upward to limit the extent to which the airflow is drawn toward the rear of the body.

Optimized shapes for the A-pillars and door mirrors limit airflow turbulence.

Edges in the contours of the C-pillars, rear combination lamps, and rear fenders limit the extent to which the airflow is drawn toward the rear of the body.

The front bumper's corners are shaped to suppress turbulence along the sides of the body.

The rear end of each side sill curves outward to limit turbulence over the rear wheel.

The bottom of the rear bumper is shaped to form a spoiler, so it smoothly [illegible] underbody airflow upward.

Aerodynamic simulation

Pistons improvement

Low-resistance pistons, low-tension piston rings, shimless tappets, and other measures against friction losses are complemented by new measures including optimized piston rigidity and shape to cut piston-related frictional resistance. Higher gear ratios contribute as well to a better fuel economy.

Optimised brakes

The overall drag in the braking system has been reduced by 25% by, for example, reducing the drag torque caused by unwanted contact between the pads and rotors of the front disc brakes from 4.9Nm to 2.3Nm. The drag reduction greatly benefits fuel economy.

For more pictures:
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