All-New 2006 Mazda

MX-5

Press Information

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EVOLUTION OF AN ICON

"Jinba Ittai" & "Lots of Fun"

Jinba Ittai—or "Rider and horse as one" in Western terms—is the essence of the MX-5. Jinba Ittai drove all of the development team's decisions, yielding a car so nimble and fun to drive that the driver and car achieve true unity. This unified rider and horse concept allowed us to create a new MX-5 that's true to the spirit of the original, exceptionally light weight, and lots of fun to drive.

Mazda MX-5 program manager
Takao Kijima

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CHAPTER 1
INTRODUCTION

February 9, 1989, marks a highly significant moment in sports car history: this is the day that Mazda presented the original MX-5/Miata at the Chicago Auto Show. By updating the classic formula that had defined fun yet affordable two seat sports cars for decades, Mazda reinvented the concept of a lightweight roadster.

Sixteen years later, Mazda's focus on driving fun has only intensified. The classic roadster continues to evolve in the Hiroshima-based company's care and the MX-5 is still the only two-seater dedicated to the idea of rider and horse as one. Proving that the MX-5 is a fundamental expression of Mazda's soul, an all-new third-generation edition was unveiled at the 2005 Salon International de l'Auto in Geneva, Switzerland. Rethinking and re-engineering the MX-5 has provided Mazda the ideal opportunity to create the purest-ever expression of Zoom-Zoom motoring.

Key changes for the third-generation MX-5 and the chapters where they are discussed in detail are:

- A body structure that uses new materials and technologies to trim weight, improve crashworthiness, and increase rigidity (Chapter 2)
- Fresh, contemporary interior and exterior designs that celebrate the iconic status accorded the original MX-5 (Chapter 3)
- Slightly larger exterior dimensions (Chapter 3) aimed at providing adequate room for tall occupants, improved comfort, and enhanced safety (Chapter 6)
- Linear and lively engines (Chapter 4)
- Improved steering, suspension, and braking systems (Chapter 4)
- Fine craftsmanship that yields a high quality appearance and many delightful features available for the first time in an MX-5 (Chapter 5)

Mazda has long produced unique and exciting sports cars. The first Mazda automobile to win world-wide notoriety was the rotary-powered Cosmo Sport launched in 1967. The RX-7, which followed in 1978, won the hearts of sports car enthusiasts and more than its share of racing laurels. Two years ago, Mazda's introduction of the RX-8 revolutionized classic sports car definitions by offering exciting design, spectacular performance, and comfortable accommodation for four adults in one innovative package.

The classic lightweight sports car is near and dear to Mazda partly for cultural reasons. The Japanese derive great pleasure from simplicity, elegance, and compactness. Traditional Noh performing arts are expressed in simple gestures. Ceremonial tea masters demonstrate fine aesthetics in very limited spaces. So the concept of a functionally elegant sports car with compact dimensions is well understood and fondly admired at Mazda.

In May 2000, the Guinness Book of World Records recognized the Mazda MX-5 as the best-selling two-seat convertible sports car in history, with 531,890 units produced to that date. In April 2005, the Guinness Book of World Records updated the number of units produced to 700,000.

Evolution of an Icon

To renew the MX-5 for its third-generation, Mazda engineers focused on evolving the lightweight sports car concept while acknowledging that this new generation must follow the tracks of a modern motoring icon. MX-5 program manager Takao Kijima not only looked ahead to understand how the motoring world's needs have changed since the original MX-5 was launched, he also looked back to pinpoint what made this Mazda so special in the eyes and hands of car enthusiasts the world over. What he found was an intensity of spirit possessed by very few sports cars.

Recalling the circumstances at Mazda that brought the original MX-5 to life in the 1980s, Kijima notes, "The driving force behind the success of the MX-5 project was the passion of Toshihiko Hirai, the engineer who proposed the car and managed its development. Hirai was convinced that Mazda needed an inimitable product to distinguish it from other Japanese makers so he drew from Mazda's heritage and adamantly persuaded other managers that the MX-5 sports car was well worth their support. When the MX-5 was unveiled after a few years of Hirai's dedicated effort, it was the first new lightweight open two-seater in more than a decade.

"Due to the first-generation MX-5's success, key elements such as the engine, unibody, and packaging carried over to the second-generation. I lead the development of that car and found that it was not that difficult to nurture a product that customers truly admired.

"The task of creating an all new third-generation MX-5 was a greater challenge because this project consisted of a blend: previous traditions joined with several innovative updates and state-of-the-art technologies that had the potential of advancing the car to new levels of performance and enjoyment.

"To select the appropriate technologies for the third-generation MX-5, I began by studying exactly how the original car came into being. Naturally, that led me to Mr. Hirai who is retired from teaching at a Japanese university. He and I collaborated on an SAE paper covering the development of the original MX-5 which focused on how Jinba Ittai—the synergy of rider and horse moving as one—was achieved through Kansei Engineering."

Research into Kansei Engineering began at the Hiroshima University ergonomics laboratory about 30 years ago. In contrast to building automobiles engineered to meet certain specific performance goals, the Kansei approach challenges the engineer's sensitivity and creativity. Emotional values such as 'fun' and 'beauty' are a higher priority than the traditional engineering indices. All the senses are involved. Kijima continues, "Instead of zero-to-60-mph acceleration statistics, Kansei Engineering helps us understand how the car feels through the driver's sense of touch, how it sounds at speed, how it looks with the top folded, and what pleasant scents can be enjoyed during a spring drive. For all intents, Kansei Engineering is the software we used to perfect the MX-5's hardware.

"We selected the Japanese artistic ritual yabusame as the illustrative symbol of Jinba Ittai. In this ritual, an archer mounted on a horse gallops past a target and shoots an arrow. To hit the target's bull's eye, the archer and horse must move as one. A natural two-way communication is essential and the horse and rider alliance must also exhibit a high degree of synergy. Updated to the 21st century, Jinba Ittai is similar to the bond between a single-seat formula-car driver and his racer or the relationship between a high-performance sport motorcycle and its rider at speed.

"Yabusame stands for the cozy driver-car relationship targeted for the first-generation MX-5. Instead of aiming for sheer speed, the goal was establishing fun-to-drive attributes as the top priority.

"Our paper pointed out that, with Kansei Engineering, the focus is not on direct measures such as performance and quality achievements but rather the intangible virtues such as pleasure, beauty, and emotional attachment. In the end, Kansei Engineering is a navigational tool that leads development engineers to study every aspect of design, mechanical function, and dynamic response in order to achieve the highest possible degree of driving satisfaction.

"To integrate Kansei values into the original MX-5, Hirai created a fishbone chart with head of the fish labeled Jinba Ittai and each rib extending from the spine of the fish labeled with key Kansei elements such as integrated feel, linear and direct feel, and so on. Notes depicting specific elements necessary to realize the Kansei attributes were positioned next to the respective rib.

"By working closely with Mr. Hirai on the SAE paper, I gained a deep appreciation of the original MX-5's developmental process. This understanding became the starting point for my third-generation effort.

"I decided that preserving the Jinba Ittai and fun-to-drive character of the first- and second-generation cars was of utmost importance in the development of the new MX-5. One of the first steps with my team was the creation of a fish-bone chart that would clarify developmental goals and spell out the means by which those goals should be realized. Each team member stated in writing how they would realize the Jinba Ittai concept within their respective development areas. To formalize their commitments, each team member's statement became part of a concept catalogue and copies of the final catalogue were issued to everyone participating in MX-5's development.

"One aspect of support I didn't have to worry much about was the backing of Mazda's top management. While sports cars are a lower priority than mainstream models at many companies, such is not the case at Mazda. Top management understands and embraces our sports car philosophy and considers driving fun the very core of Mazda's Zoom-Zoom strategy. As a result, management and the MX-5 development team worked together as one.

"Throughout this effort, those nurturing the new MX-5 regarded their car as something more than a machine. Thanks to its fun-loving character, it's capable of bringing happiness and enrichment to its owners. In contrast to today's consumer culture where convenience and efficiency outrank simple pleasures, MX-5 is a warm companion that exhibits a genuine enthusiasm for motoring. I'm very confident that the MX-5 we've engineered is the ultimate lightweight sports car and solid proof that Mazda is serious about building and selling products that are great fun to own and drive."

Lots of Fun Concept

Throughout the 16 years of its existence, the MX-5 has always been defined in terms of the fun it delivers. This distinctive character is called 'lots of fun' by Mazda because the pleasure delivered includes but goes beyond driving enjoyment. In addition to providing the driver a sense of command over a spirited machine, the MX-5 offers the driver and passenger a sense of being in intimate touch with their surroundings. Other dimensions are the pride conveyed by the MX-5's attractive design, the enjoyment of customizing its appearance and function to suit personal tastes, and the joy of meeting friends in a car that's so universally admired. Fun is truly a multidimensional MX-5 quality.

Recognizing this special characteristic, the core product concept of the new MX-5 is "a car in which Jinba Ittai dynamics and lots of fun are carried forward and evolved for another generation."

Evolution of Jinba Ittai

Although Kijima was the chassis specialist for the first-generation and program manager for the second-generation, a lot of soul searching by team members was necessary because few others had participated in the development of the first- or second-generation MX-5 models. By driving competitive sports cars and the current MX-5 extensively in wide-ranging conditions, these members soon identified those attributes that should continue unaltered and other qualities that warranted updating for life in the 21st century.

Nearly 100 team members created a catalogue expressing their personal passion for the "rider and horse as one" concept and the means they intended to use to instill the MX-5 with this emotion. One example: Chief Designer Yasushi Nakamuta pledged "to create a design which gives FUN to people every time they see, touch, and drive the car by combining lightweight sports car virtues—such as simple beauty and function—with a very direct feel and a meticulous shape for every part."

Distinctive packaging was the first attribute selected for preservation. Maintaining the original car's front-engine, rear-wheel-drive, open-cockpit, two-seat basic layout was deemed a better means of achieving driving enjoyment than simply creating a car with superior performance. Therefore fundamental features from the first-generation—the front-midship engine location, double wishbone suspension systems, a snug cockpit, and a powerplant frame linking the transmission to the differential—were passed on to the third-generation. And given the universal admiration for the MX-5's exterior design proportions, the essence of that look was also deemed worthy of preserving.

Since the original and the second-generation MX-5 were created, sports car buyers have become much more environmentally aware and more interested in features aimed at protecting their safety. In order to address those concerns in the third-generation MX-5, the development team searched for appropriate advanced technology to improve safety and comfort.

New Fish Bone Chart

The long list of attributes that ultimately lead to the Jinba Ittai goal line—oneness between car and driver—were arranged in six new fish bone categories: driving, braking, cornering, listening, touching, and styling. Then, to achieve true synergy between those discrete categories, a cooperative framework was created to help developmental team members be more aware of the progress of the entire engineering process.

Four of these cross-disciplinary categories drawn from Kansei Engineering principles are:

LIGHTNESS

Even though the new MX-5 is slightly larger than its predecessors, keeping it as light as possible improves every aspect of performance. A gram strategy (discussed in detail in the next chapter) was critical to the lightweight cause. Related imperatives are a low center of gravity, 50:50 weight distribution, and the lowest possible moment of inertia in the yaw plane.

CONSTISTENCY

The balance and natural interaction between driving, cornering, braking, and listening aspects requires a harmonious approach. A special team was created to study various components—shifter, steering wheel, control pedals, etc. with the aim of achieving a high degree of balance and consistency in the car's overall personality. Liveliness and nimble behavior in every dynamic move were deemed critical to maximizing driving enjoyment. Handling was selected as the MX-5's focal point and every other performance aspect was drawn into harmony with that primary criterion.

PERFORMANCE FEEL

How the car feels in the hands of a sensitive driver was subdivided under five descriptive headings—linear, lively, powerful, torqueful, and smooth. This emphasizes the more subtle tactile relationship between car and driver over raw indices such as acceleration and cornering-g figures. Establishing these subheadings helped coordinate the evaluation and optimization of all the performance attributes.

CRAFTSMANSHIP

In addition to static attributes, the development engineers also concentrated on new dynamic aspects of craftsmanship. To this end they conducted in-depth research into the dynamics of driver behavior, focusing on the driving position, the layout, operation and feel of the controls, the harmonic engine sound, the tactile aspects of the interior design, and outward visibility.

CHAPTER 2
WEIGHT REDUCTION AS THE TOP PRIORITY

Mazda's "Gram Strategy" - The Ultimate Weight-Saving Imperative

There's a natural tendency for curb weight to rise when car manufacturers respond to market demands for more comfort, greater occupant protection, and better environmental responsibility. Realizing that this is contrary to the Jinba Ittai goal and that extra weight has a dramatically negative influence on driving, cornering, and braking performance, Mazda engineers made every gram count. (In the English measurement system used in the US and elsewhere, one pound equals 454 grams.) Their "gram strategy" assessed weight in the smallest possible increments. For example, simplifying the rearview mirror's design trimmed 84 grams (0.19 lb). But applying this strategy throughout every nook and cranny of the MX-5's design proved to be a very effective means of building a very light sports car that met all of its market demands.

Targets were set for the total vehicle's weight—at 1,128 kg or 2,487 lb for the base MX-5—and also for the weight of individual parts and systems. All 16 Product Module Teams (PMTs) then set about designing the components they were responsible for with their weight targets firmly in mind. Major opportunities for saving weight by changing the decklid from steel to aluminum and the engine block from iron to aluminum were naturally accounted for in the initial targets. Only then, in order to close the gap between each PMT's weight target and the weight of the components they were responsible for, was the gram strategy employed.

Mechanical prototypes were carefully scrutinized for every possible weight savings opportunity. More than 100 PMT engineers also examined three-dimensional models of the upper body and interior components in search of excess weight. Later, when completed running prototypes became available, they too were studied part-by-part, detail-by-detail for ways to trim weight one gram at a time.

Notebooks compiled list a total of 573 ideas representing a total of 43.589 kg (96 lb) that were considered as weight savings measures. Of course many were rejected as unsuitable from strength, reliability, or crash-performance standpoints. But a lot of ideas—like trimming metal flanges, eliminating excess quantities of lubricant and shortening the length of fasteners—were employed to achieve the MX-5's ambitious weight target.

Well before the gram strategy was employed as a final measure to reach the weight target, the basic unibody was designed using high-strength, low-weight materials capable of delivering the desired rigidity and the lowest practical weight. Three fundamental weight-saving policies were: to use thin material in large cross-section structures within the wheelbase in the interests of high rigidity; to use the minimal amount of sheet metal in overhang areas; and to incorporate as much ultrahigh-strength steel in the thinnest possible gauge to meet crashworthiness goals.

High-strength steel comprises 46-percent of the new MX-5's body structure by weight. Twelve percent of the unibody is made of ultra-high-strength steel which has nearly three times the yield strength of ordinary steel. The net savings attributable to this approach is approximately 10 kg (22 lb). The complete body-in-white weighs 247.5 kg (546 lb) which is 1.6 kg (3.5 lb) less than the previous MX-5 in spite of major reinforcements added to improve crashworthiness and dimensional increases necessary to accommodate larger-stature occupants.

Use of aluminum for the hood, deck lid, power plant frame, front suspension control arms, rear hub carriers, rear brake calipers, and rear suspension spring seats trimmed additional grams. Furthermore, the new engine's intake manifold and cam shaft cover are molded of lightweight composite-plastic materials. The block of the previous 1.8-liter engine was cast-iron while the new 2.0-liter engine has an aluminum block with thin cast-iron cylinder liners. With accessories added, the net weight savings attributable to the engine alone is a substantial 19.1 kg (42.1 lb).

Mounting the power steering pump and the air-conditioning compressor directly to the engine block eliminated separate brackets weighing 3.2 kg (7 lb). Using a hollow tube instead of a solid rod for the front anti-roll bar trimmed another 2.4 kg (5 lb). Optimization of fixed structures in the steering system achieved another 0.6 kg weight saving. High-strength steel has also been specified for seat backs and cushion side frames yielding a net savings of 4.8 kg (10.6 lb).

The gram strategy also met success in brake and steering systems.

In final form, the new MX-5 is larger, more powerful, more capable, more comfortable, and more useful. It offers several new features and greatly improved occupant protection from collision injury. Yet, thanks to Kansei Engineering and Mazda's gram strategy, the MX-5's base curb weight is only increased by approximately 10 kg (22 lb).

While saving weight is a top priority for achieving Jinba Ittai, because a lower weight improves every aspect of performance including fuel efficiency. Other concerns were the stiffness of the unibody structure, the height of the car's center of gravity, 50:50 weight distribution, and the MX-5's moment of inertia about a vertical (yaw) axis. (A lower yaw moment of inertia quickens the vehicle's responsiveness to the driver's steering commands.) Each of these parameters strongly influences the final design's overall fun-to-drive characteristics.

A stiff body structure is an essential ingredient in the feeling of oneness between the car and its driver. Thanks to shrewd analysis and the application of advanced materials, the new unibody is 22-percent stiffer in bending and 47-percent stiffer in torsion compared to the previous MX-5.

Moving the engine rearward by 135 mm (5.3 in) was a major step towards balancing front-to-rear weight distribution and reducing the yaw moment of inertia. Both the battery and the fuel tank were shifted forward to new locations closer to the center of gravity. The fuel tank was also lowered substantially. Slanting the top of the radiator forward also helped lower the center of gravity. The MX-5's total yaw inertia is reduced by a significant two-percent.

With two occupants on board, each axle carries approximately 50-percent of the load (50:50 weight distribution). (Fully loaded with fuel and luggage, the rear wheels carry slightly more weight than the front wheels. At curb weight—no driver, no luggage, full fuel tank—there is a slight weight bias in favor of the front wheels.)

World's First Spot Friction Welding between Steel and Aluminum

One example of advanced technology employed to save weight is spot friction welding used to join steel stud plates to the MX-5's aluminum decklid panels.

It is normally difficult to join aluminum and steel by welding. To overcome this problem Mazda developed new welding technology that employs a special high-speed spinning tool. As the blade edge of the welding tool spins and comes into contact with the aluminum, the heat generated by plastic deformation of the aluminum softens the steel sheet directly beneath. Continuously applied pressure removes the zinc plating from the surface of the steel sheet, bringing the aluminum and steel sheet into direct contact and joining them. The zinc serves to prevent bimetallic corrosion that normally occurs at this point. Thanks to this spot friction welding technique, the large current used in resistance spot welding is not required, and each weld is completed in a few seconds. Mazda engineers have applied for 20 patents to cover this innovative technology and expect to use it extensively in the future to achieve worthwhile weight savings in other vehicles

CHAPTER 3
DESIGN

The exterior design of the new MX-5 began with the understanding that two previous models had earned a large and enthusiastic following all over the globe in large part to their appearance. With this in mind, the most distinctive styling elements - specifically the curves and proportions evident in the side view - were retained in the new third-generation design that still celebrates the fundamental appeal of a lightweight sports car.

Exterior Design

Simple. Contemporary. Fun. Friendly. These are words that capture the essence of a successful lightweight sports car. But achieving simple, clean elegance in a new design that will appeal to a large number of customers located around the globe is no small feat. The MX-5 design process required over a year of dedicated effort in three studios, an endeavor that was led by Mazda's chief designer Yasushi Nakamuta. To inspire his team with the theme of the new third-generation car, Nakamuta provided these words of guidance, "The MX-5 has become an icon for the lightweight sports car. As a result, the new MX-5 should convey FUN and MODERN styling while paying homage to the original (first-generation) design. It should exemplify lightweight sports car functionality and athletic solidity. By embodying the simple, approachable design elements in a fresh way, it will be quickly and easily identified."

After visiting Mazda studios in Irvine, California, Frankfurt, Germany, and Hiroshima, Japan, and studying conceptual sketches produced by the three studios, Nakamuta combined their work in the above design concept summary. Various pertinent details - such as the length of the wheelbase, packaging requirements, potential customer delight features, and new technologies - were then passed down to the global design team. Working with quarter-scale clay models, a total of seven design proposals were crafted.

Three of those models - one from each studio - were then selected for completion as full-scale clay models. US designers were asked to pursue the "newness" direction with an even trendier and more revolutionary design. Europe held true to its evolutionary path. Hiroshima designers focused on the creation of an oval motif stressing compactness.

When those three full-size clay models were examined in the presence of the current MX-5 and three key competitors in a wide-open area at Mazda's Miyoshi proving grounds, it was clear that the American design looked fresh, new, and attractive but it lacked the feeling of compactness. In contrast, the European and Japanese proposals both embodied the desired compact roadster image. So the selection was narrowed to two proposals for the final selection: the very clean and compact proposal developed by the Hiroshima studio did the best job of capturing the distinctive lightweight sports car spirit of the original MX-5 with new surface expressions and a wealth of updates.

In a sports car, the impression of athletic muscularity comes more from the movement and expression of body contours than from its character lines. With this in mind, designers focused on light reflections and shadows in the body shape to achieve an appearance that varies with viewing angle.

The first- and second-generation MX-5 exterior design is a rounded shape with a wide footprint, large-radius corners, and deep side contours. A key change for the third-generation is the elimination of the coke-bottle-shaped center section; instead, the designers employed an entirely new oval shape in which the seating area is now the widest portion of the car. The oval shape makes for a roomier interior, and while assuring the latest in crash-safety, expresses the compact look befitting a lightweight sports car. Prominently flared fender arches emphasize the width and importance of the wheel tracks while aggressively rounded nose and tail shapes express the MX-5's leanness, athleticism, and simplicity.

With respect to the second-generation MX-5, the third edition is 40 mm (1.6 in) longer, 40 mm (1.6 in) wider, and 15 mm (0.6 in) taller. The length of the wheelbase is increased by 65 mm (2.6 in). So the resulting basic dimensions for the third-generation MX-5 (North-America specifications) are:

- Wheelbase: 2,330 mm (91.7 in)
- Overall length: 3,990 mm (157.1 in)
- Overall width: 1,720 mm (67.7 in)
- Height: 1,245 mm (49.1 in)
- Track, f/r: 1,490/1,495 mm (58.7/58.9 in)

Major Exterior Design Elements

Key MX-5 side-view design details are:

- A low, flowing shoulder line with a slight wedge shape conveys a sense of forward motion and speed.
- Crisp surface treatments on softly rounded side surfaces create reflections and shadows that draw the eye from front to rear areas.
- Strong fender arch lines wrapping around the wheels are a statement of Mazda design DNA.
- Door mirrors that continue the elliptical theme established by the original MX-5.
- Five-spoke 16-inch aluminum wheels that radiate a sense of simplicity and strength. Ten-spoke 17-inch aluminum wheels that suggest one set of five spokes superimposed over a second set of five spokes, lending a high-quality, sporty impression.

The more prominent front and rear highlights are:

- The inboard position of the head- and taillamps impart a sense of compactness.
- The rounded grille opening is carried over with modest alteration from the original MX-5 design.
- A shorter and more aggressively rounded hood opening line facilitates a cleaner and more dynamically contoured front bumper fascia.
- The headlamp design is a major update from previous MX-5 configurations. The lens cover is shorter in height but steeply slanted to sweep around the corner of the car.
- The taillamps combine the traditional and immediately recognizable elliptical shape from previous design generations with highly contemporary materials.
- Seat backrest hoops add an eye-catching detail in the rear view.

The soft top is recontoured to provide a sportier, more classic appearance with a flatter upper surface and a longer rear contour that flows smoothly into the deck. The lowered shape blends smoothly with surrounding body contours so well that no separate cover is needed. The new Z-fold design creates a more impressive roof.

The detachable hard top has a sweeping shape that widens out to the rear windows, expressing a lighter, more modern and aggressive look.

Carefully tuning the MX-5's exterior shape yielded good aerodynamic performance which enhances the feeling of pace and stability at high speeds. Side skirts, tire-area deflectors, and the front spoiler are designed to control air flow under the body and along its sides, thereby minimizing the creation of drag-increasing vortices.

Seven shades of paint are offered including Velocity Red Mica, which is only available on the 3rd Generation Limited. Out of these there are three newcomers: Galaxy Grey and Copper Red, which are suitable for a modern sports car image, and True Red for the more traditional sports car look.

Interior Design

The goal of the interior design effort was to stimulate excitement for the joy of driving an open lightweight sports car unencumbered by complexity. One key change from the second-generation MX-5 is providing more elbow room and seat travel to accommodate a wider range of statures without losing the intimate feeling and handy ergonomics of a lightweight sports car. (Specific details related to roominess and comfort are covered in Chapter 5.)

Digital design studies using three-dimensional modeling software helped configure the MX-5's cabin. Where possible, the latest textures, surface treatments, and styling idioms were applied. Furnishings critical to the driving task such as the instruments and controls are located for ease of use. A look of purity and precision is provided. Excellent fit and finish standards enhance the impression of fine craftsmanship.

The interior design theme is balancing the feeling of comfortable snugness below shoulder level with openness above that height to lend the impression that the car's occupants are riding in open air.

The T-shaped instrument panel is consistent with Mazda DNA while the center console accentuates the backbone of the car. Strong horizontal and vertical theme lines connote rigidity and sports-car capability. The black center stack is as simple and as functional as possible. The arched hood over the instrument cluster and four circular vent registers give the MX-5 interior its identity.

Two large and three small dials are each trimmed with a silver-finished ring. Each stands proud of the cluster's rear surface and each instrument has its own low-reflection lens. The needles on the speedometer and tachometer have a 6 o'clock starting position, which is perfectly apt for a sports car. Illumination is provided by amber light sources behind the dials. Needles are white for maximum contrast against the black dial faces. They twitch in anticipation of what's to come when the ignition is switched on.

The small-diameter steering wheel has three thick metal-accented spokes. A very compact doughnut-shaped air bag surrounds the central horn button which is adorned with the Mazda wings brand badge. For the first time audio and cruise-control switches are mounted to the spokes and MX-5's equipped with the six-speed Sport mode automatic transmission are fitted with handy shift paddles.

Two covered cupholders are located on the top surface of the center console behind the short shift lever. Console trim has a ribbed surface finish selected for its contemporary high-quality appearance and durability advantages. A cylindrical receptacle is also provided in the lower, front corner of each door surface.

Two levels of interior trim are offered: fabric and leather. The fabric interior is an attractive monotone package with black fabric seat upholstery and silver-finished accents on the steering wheel, gauge rings, and inner door handles. The black leather interior provides a more elegant high-tech look; prominent stitching with heavy thread enhances the appearance of the soft trim. There is also an alternative saddle brown leather with the feel of expensive footwear, horse saddles, and designer luggage. Areas of the dash and doors are finished with two-tone black and saddle brown trim. Silver-finished accents are provided for the door handles, door assist grips, and speaker rings.

For the 3rd-Generation Limited model, exclusive red leather seats nicely match the exterior of the car and offer excellent support and an ideal driving position. The interior is also outfitted with chrome-silver design elements and unique numbered badge stating the sequential production number.

Extra effort was invested in making the new MX-5 interior far better than its predecessor for storage convenience.

Key features are:

- A 5.7-liter (347.8-in3) locking glove box.
- A small item recess at the bottom of the center stack.
- On the driver's side at the bottom of the instrument panel, a small box for sunglasses or a cell phone is provided.
- Ticket holders are built into each sun visor.
- Each door pocket is shaped to hold beverage containers up to half-liter in size.
- Storage net attached to the center tunnel on the passenger's side (GS/GT).
- A locking box large enough for 10 CDs is built into the trim covering the center portion of the rear wall of the cockpit. Two more storage compartments are located in the rear wall behind the seats.
- Passenger seat-back pocket.

To maximize the space available, the trunk contains a puncture repair kit in place of a spare wheel and tire assembly. Furthermore, the floor of the trunk is lower to permit space for a case that carries 1.5-liter size beverage bottles upright. A capacity of 150 liters (5.3-ft3) represents a four-percent increase over the previous MX-5's trunk capacity.

CHAPTER 4
DRIVING DYNAMICS

Achieving Jinba Ittai in a Lightweight Sports Car with Kansei Engineering

Whether it's called Jinba Ittai, rider and horse, or happy-face motoring, driving fun in a highly responsive open roadster is a cross-cultural experience that is appreciated in every corner of the globe. Mazda revived this simple pleasure with the launch of the original MX-5 in 1989. With the arrival of a third-generation roadster this year, Mazda engineers seized the opportunity to continue the best features from two previous models while adding new MX-5 dimensions to assure that Mazda's Zoom-Zoom spirit continues to thrive in the 21st century.

Takao Kijima's development team identified five core requirements for achieving of a fun-to-drive personality:
- Lightness
- Optimal weight distribution
- A priority on handling
- A consistently nimble, natural feel
- Dynamic-feeling performance.

The pursuit of the lightest possible weight and the advanced technologies selected to achieve a third-generation MX-5 that, in spite of being larger in nearly every dimension, is only about 10 kg (22 lb) heavier in base weight than the car it replaces are covered in detail in Chapter 2. This chapter will focus on the four other core requirements and the details of the chassis and powertrain components engineered to achieve them.

Optimal Weight Distribution

To insure that the driver's control requests are faithfully and expeditiously fulfilled by the car, its weight should be balanced equitably between the front and rear axles. The optimum sports car has the lowest possible center of gravity (cg), the lowest possible moment of inertia in the yaw plane [major masses located closely to a vertical axis through the center of gravity], and half of the total weight of the vehicle and its occupants carried by each axle.

These principles guided the general layout and development of the MX-5. In spite of the new car's slightly larger size, higher level of standard equipment, and its larger and more powerful engine, Kansei Engineering has allowed Kijima's team to achieve the aforementioned core requirements such as the optimal 50:50 front/rear weight distribution.

To lower the yaw moment of inertia by two-percent with respect to the second-generation MX-5, major masses have been moved closer to the center of the car. For example, the engine is moved rearward by 135 mm (5.3 in), facilitated by an HVAC unit that's seven-percent smaller than before and an extra 20 mm (0.79 in) of distance between the driver and passenger. Moving the battery - now changed to a standard type for lower maintenance costs - from the trunk to a new location ahead of the engine diminishes its distance from the cg by 265 mm (10.4 in).

The fuel tank has been moved forward by 110 mm (4.3 in) and lowered by 120 mm (4.7 in) from its previous position in the trunk to a new underfloor location. The net change in the MX-5's cg height is a worthwhile 18 mm (0.71 in).

Thanks to the Jinba Ittai emphasis and Kansei Engineering strides, the new MX-5 sets an enviable standard in terms of light weight, cg height, and polar moment of inertia. A few sports cars do top it in certain categories: some are lighter, some have lower cg and lower moment of inertia, etc. But the development team believes that there is no lightweight sports car with the MX-5's combination of design virtues capped by an affordable price.

A Priority on Handling

Clear and specific handling targets were established to assure that this attribute rose to the top of the requirements list. A particular emphasis was placed on achieving a brisk, nimble feel which sometimes causes diminished stability and undesirable sensitivity to external forces such as road irregularities and crosswinds. With this in mind, the development team sought a balance wherein the rear of the car maintains an unshakable grip with the road for maximum stability while the front of the car is solely responsible for initiating directional changes requested by the driver. To achieve highly consistent grip over various road surfaces and during changes in braking or power delivery, the development team selected highly linear control of the toe (steering) and camber angles as well as the vertical forces applied to each tire. At the rear of the car, a new multilink suspension system was selected because this approach offered the most freedom in selecting the ideal geometry for all wheel movements.

To minimize the amount the rear of the car rises during braking, front and rear suspension systems are configured to provide a strong anti-dive effect. Suspension links are arranged to convert a portion of the braking force fed into the body into a moment which counteracts the natural tendency of the body to pitch slightly down in front, up in back. Minimizing the dive movement also minimizes rear-wheel travel and unwanted changes in toe and camber. The net improvement over the second-generation MX-5 is a 38- percent reduction in dive during braking.

A similar technique is used to control the body's tendency to squat during acceleration. Arranging the rear suspension links to provide an anti-squat effect again minimizes rear-wheel travel and unwanted toe and camber deviations. The net effect is 78-percent less squat than in the second-generation MX-5 and a more stable feeling rear grip that's undisturbed by changes in throttle position or brake applications.

To achieve a feeling of nimbleness and willingness to change direction in response to steering inputs, the development team focused on achieving maximum rigidity throughout the steering system. The diameter of the steering rack was increased from 23 mm to 24 mm (0.91 in to 0.94 in) in the interests of higher stiffness, the torsion bar that opens the power-steering assist control valve is stiffer, and the pinion gear and control valve have been integrated into one assembly.

At the rear of the MX-5, the subframe that supports the differential and suspension links is attached to the unibody at six points so lateral forces result in minimal deflection. Together these measures help minimize the lag between steering input and car reaction.

Achieving a Consistently Nimble, Natural Feel

Competitive sports cars achieve excellent performance without necessarily providing a natural feeling of nimbleness in all driving situations. To raise the MX-5 above that level of achievement, a special group of test experts was assigned the task of applying Kansei Engineering to quantify subjective aspects of handling, to analyze these aspects in detail, and to find the means of providing a consistently nimble and natural feel in all driving situations.

As a first step, consistent performance character was defined as an operating feel through the steering wheel, accelerator, brakes, and other controls that is light and predictable in all driving situations. Also, all running, turning, and stopping movements should convey a feeling of nimbleness. To study these characteristics in fine detail, the team focused on six specific situations wherein any driver could experience the new MX-5's signature nimble and natural handling:

- Entering a main road from a parking lot
- Turning at a road junction
- Driving through urban or suburban traffic
- Driving on winding roads
- Joining freeway traffic
- Passing on the freeway.

The team quantified nimbleness by plotting steering response versus steering effort for all MX-5 generations and various competitors in order to select a target point for the third-generation edition. Another measure documented and studied was the amount of change in the rate of acceleration (ΔG) after the throttle was opened.

This same procedure was used to coordinate accelerator pedal, clutch, steering, and shift efforts. In each case, a consistency line was plotted and control variables adjusted to achieve a highly consistent feel throughout each driving operation.

Another important criterion for sporty driving is the lateral restraint provided by the driver's seat. By studying the pressure distribution in the seat back and cushion, it was possible to improve the level of lower-back hold during cornering. This index was also plotted versus steering gain (vehicle response speed to steering) and steering force as part of the consistency effort.

Dynamic-Feeling Performance

A key part of the desired lively feel is how a push of the throttle translates into forward acceleration. Initially there's a surge followed by gradual convergence toward a steady forward acceleration. Making that convergence as rapid and as tight as possible greatly improved the MX-5's sense of directness and liveliness. Increasing the stiffness of driveline components and reducing yaw inertia of rpm are obvious means of speeding this convergence. A computer-aided engineering system was very helpful in modeling, testing, and analyzing this aspect of driving. In practical terms, we shaved weight off of the flywheel, tuned the electronic throttle, further bolstered propeller shaft stiffness and optimized the engine mountings.

The engine's ability to continue producing a strong flow of torque at very high rpm is another highly sought after sports car attribute. Mazda engineers call this "extensibility." The requirement is a very flat torque curve with minimal wilt after the peak value. In the MX-5 various tuning measures were applied to achieve this important characteristic.

How the engine sounds is arguably the most critical phase of the sports car experience. Here a driving simulator was used to clarify the relationship between acceleration rate and engine sound. The team's conclusion was that a harmonic, linear sound was most appropriate during acceleration. (Tuning the engine's note through all operating regimes is discussed in full detail in Chapter 5's Dynamic Craftsmanship section.)

Given the MX-5's global reach, engineers spent ample hours in faraway places tuning and testing prototypes. There were four week-long trips to drive on US roads, a month spent evaluating winter performance in both New Zealand and Sweden, three visits to two Japanese race tracks, and nine trips to England and Europe. High-speed dynamics were studied on German autobahns. Nearly two weeks were spent exploring the ragged edges of the performance envelope on the 73- turn, 21 km (13 mi) Nurburgring Nordschleife circuit where the new MX-5 bettered the second-generation model's lap time by 15 seconds.

CHASSIS DETAILS

Front Suspension: The new MX-5's front suspension is a double-wishbone (also known as unequal-length control arm) design similar to what has been used before but with revised geometry. In the interests of controllability, these control arms are long to provide linear toe, caster, and camber changes as the wheels travel up and down. Anchor points are reinforced to provide the desired lateral stiffness. Special rubber bushings with a zero-clearance-stopper- structure and internal metal sleeves provide the desired amount of road isolation while limiting the fore-and-aft wheel movement, an aid to linearity. Control arms are aluminum to provide the necessary strength and stiffness with minimal unsprung weight. Upper arms are made using a semi-solid die-casting method called rheo-die-casting. The more heavily loaded lower arms are forgings.

The dampers are a gas-filled monotube design with a 45 mm (1.77 in) piston diameter in place of the twin-tube design used previously. As a result, damping is more effective and consistent especially during small wheel movements. The damper attachment point is much closer to the wheel than in the second-generation MX-5 to provide more damping for each increment of wheel movement. The strut towers directly connected to upper anchor point for each coil-damper unit are braced to the cowl structure for utmost handling stability and judder-free ride motions. On GS models, the standard dampers are replaced with Bilstein units that have their own Dynamic Stability Control calibrations.

Rear Suspension: On the new multilink rear suspension, the five links that locate each rear wheel are also long in the interests of highly linear geometry. The layout is designed in consideration of compliance control, to insure that the reaction force of spring and damper is continuously applied to the links. The bottom end of the gas monotube shock absorbers are anchored directly to the aluminum wheel spindle carrier to provide maximum damping efficiency. The hydroformed steel subframe to which the suspension links attach is bolted directly to the unibody at six points to enhance overall chassis stiffness.

Steering: The power-assisted rack-and-pinion steering system is an improved version of the second-generation MX-5 design. Notable changes are 0.6 kg (1.3 lb) less weight and higher rigidity thanks to a 1 mm (0.04 in) increase in rack height. Special features are a non-return pump design with a one-way outlet port that prevents kick back from bumps in the road to the steering wheel. Power assist is engine-speed sensitive.

Brakes: Improvements with respect to the out going MX-5's four-wheel disc system are greater linearity, quicker response, and better controllability. The amount of pedal stroke needed to produce a given amount of deceleration and the play in the linkage are both reduced. The pedal ratio is changed from 4.1 to 2.9 for a more direct feel. Front rotors are ventilated and increased in diameter by 20 mm (0.78 in) to 290 mm (11.4 in). Rear rotors are solid and increased in diameter by 4 mm (0.16 in) to 280 mm (11.0 in). The vented front rotors are 22 mm (0.87 in) thick while the rear solid discs are 10 mm (0.40 in) thick. The cylinders that activate the rear brake calipers are 3.3 mm (0.13 in) larger in diameter to shift overall braking balance more toward the rear wheels.

Thanks to a new electronic brake force distribution algorithm, the rear brakes work harder with little danger of lock up. The vacuum booster is 25 mm (1.0 in) larger in diameter to provide the assistance needed during very hard brake applications. Response and linearity are both improved over the past design. Front and rear brake system rigidity is 25-percent higher, also for linear response. A stiffer material for the reinforcement braid used in the brake hoses results in far less swelling and loss of linearity at high temperature. These improvements yield a braking distance of 38.4 m (126 ft) from 100 km/h (Mazda measurement, cold conditions), which is one of the best measurements in the class.

Thanks to the new combination of increased braking power, larger tire sizes, minimal increase in weight, and better suspension geometry, overall stopping performance is significantly improved.

Wheels: Aluminum wheels are available in 6.5x16 and 7.0x17 sizes. Two different designs are offered: 16-inch with five spokes and 17-inch with ten spokes.

Tires: Models with 16-inch wheels come with 205/50R-16 tires and those with 17-inch wheels 205/45R-17 tires. No spare wheel is included with any MX-5 as a weight-saving measure. Instead, a puncture repair kit is provided.

POWERTRAIN

Engines: Light, compact, highly responsive, powerful MZR engines with appropriately sporty intake and exhaust notes were developed to assure that the MX-5 is brisk, nimble, linear in response, and very fun to drive. Based on the acclaimed MZR engine series installed in other Mazda models, these engines are front-midship mounted on the MX-5 and adopt the latest technologies developed to boost power appropriately for a lightweight sports car while supporting environmental compatibility with greater fuel-economy and reduced emissions.

Powertrain lineup by market

Engine	Transmission	North America	Europe	Japan	Australia
1.8L	5-speed manual	–	0	–	–
2.0L	5-speed manual	0	0	0	–
	6-speed manual	0	0	0	0
	6-speed Sport mode	0	–	0	0

Key features of the MZR family are aluminum block and head construction with iron cylinder liners, chain-driven double-overhead camshafts, variable intake-valve timing, electronically controlled sequential-delivery port fuel injection, and coil-on-plug ignition.

The compression ratio is 10.8:1 and an 83.1 mm (3.27 in) stroke. The bore in the 2.0-liter engine is 87.5 mm (3.44 in). The range of intake valve opening and closing variability is 30 (camshaft) degrees. The bucket tappets have low-maintenance shims for lash control. Piston skirts are coated with a molybdic antifriction compound.

Overall engine length was trimmed by 69 mm (2.72 in) compared with the second-generation model by thoughtful location of external components. Tilting the engine 10 degrees to the right provides room for a large, low-restriction Variable Intake System (VIS) with two operating modes to enrich the torque curve. VIS is tuned with an emphasis on odd and half-order harmonics at high rpm to provide a lively, robust engine note.

Peak output of the 2.0-liter engine is 170 hp at 6,700 RPM with a manual transmission. At least ninety percent of peak torque is available from 2,500 rpm to the 6,700 rpm redline. (The fuel cut-off is at 7,000 rpm.) Response has been tuned by use of a flywheel lightened by 0.3 kg (0.7 lb), a large electronically controlled throttle, and very rigid drive shafts.

Engine specifications (Provisional data)

	MZR 1.8	**MZR 2.0**		
Transmission	5-speed manual	5-speed manual	6-speed manual	6-speed Sport mode
Displacement (cc)	1,798	1,999		
Bore x stroke (mm)	83.0 x 83.1	87.5 x 83.1		
Compression ratio	10.8	10.8		
Max. output	EU: 93kW (126PS)/ 6,500rpm	NA: 170hp/6,700rpm EU & AUS: 118 kW (160PS)/6,700 pm JPN: 125kW (170PS)/6,700rpm		NA: 166hp/6,700rpm AUS: 118kW(160PS)/6,700rpm JPN: 122kW (166PS)/6,700rpm
Max. torque	EU: 167Nm/ 4,500rpm	NA: 140lb-ft/5,000rpm EU & AUS: 188Nm/5,000rpm JPN: 189Nm (19.3kg-m)/5,000rpm		NA: 140lb-ft/5,000 rpm AUS: 188Nm/5,000rpm JPN: 189Nm (19.3kg-m)/5,000rpm

NA: North America, EU: Europe, JPN: Japan, AUS: Australia

Transmissions: The five-speed manual transmission is carried over from the second-generation MX-5 with key changes. To handle the additional torque, the inner structure of the transmission, the counter shaft, and third gear are stronger. Triple-cone synchronizers for first and second gears, double-cone synchros for third, and a carbon-type synchro for fourth reduce shift effort.

Gear ratios in the newly engineered six-speed manual transmission are purposely close to enhance the joy of sporty driving. Short, quick shift strokes have been achieved by use of triple-cone synchros on the first four gears. To reduce inertia, the third-fourth synchro is located on the counter shaft. For positive feel, the shift linkage is a single unit supported by low-friction bushings and guided by a steel plate.

As a convenience, reverse is located adjacent to first gear. Accidental engagement is prevented by the need to press down on the shift lever in order to select reverse gear.

A new Sport mode automatic transmission adds a fresh dimension to the MX-5's driving personality. Six ratios are provided with wide spacing in the interests of fuel efficiency. First gear is 31-percent lower than the second-generation MX-5 automatic to provide a very aggressive launch performance. Sixth gear is 21- percent higher for high mileage and quiet highway cruising. Steering wheel paddle shifters are available on the GT model. Paddles mounted behind the steering wheel command upshifts while buttons positioned on the spokes are used for downshifts. Coordinating engine torque with the shift sequence results in smooth, seamless, and fast gear changes.

BODY RIGIDITY

As mentioned in Chapter 2, as a result of employing ultra-high strength and high strength steel sheet as well as advanced analytical technology, compared with the second-generation MX-5, bending rigidity has been improved by 22-percent and torsional rigidity by 47- percent. Additionally, the rear of the transmission is rigidly linked to the front of the differential housing by a Z-shaped power plant frame made of pressed aluminum. This assures that the driver's throttle inputs are faithfully and promptly conveyed to the rear wheels, ensuring the maximum possible oneness between car and driver.

The high-mount backbone frame running along the top of center tunnel from the rear of the dash panel is joined fore and aft to the main frame in continuous closed section. This improves body stiffness and energy absorption during collisions without imposing significant weight penalties. Bolting lateral under-tunnel members directly to the seat anchor points enhances rider and horse oneness by minimizing seat flexibility and vibration.

TECHNOLOGY AND ARCHITECTURE SHARING

The Mazda R&D team has developed new architecture designed for the future of the sports car. The team capitalized on experience gained in developing the technology and architecture of the RX-8 in the development of new MX-5—model that has the same Mazda sports car DNA. Though these two sports cars do not share essential components, each is designed with the optimal parts and layout for the particular model. This section contains a description of the technology and architecture shared by the two sports cars.

What can be said with all certainty is that both the RX-8 and the MX-5 are sports cars infused with Mazda's unique Zoom-Zoom spirit. Each model delivers the most driving fun and the best blend of performance attributes and value available in its respective class.

In pursuit of driving excellence, the RX-8 and MX-5 also share a fundamental configuration: the front-mid-engine, rear-wheel-drive layout Mazda has perfected with near-50:50 weight distribution. Both cars strive for light weight, a low center of gravity, and a low polar moment of inertia because such characteristics are in the best interests of dynamic performance - handling, accelerating, braking, steering response, and stability at the limit of adhesion. Both the RX-8 and MX-5 have a powerplant frame joining the transmission to the differential. Other common traits are the suspension and brake systems.

But unlike the RX-8, which is a rotary-powered sports car for four, the MX-5 is a lightweight two-seater sports car with a Jinba Ittai spirit that's extremely fun to drive. Since the MX-5 has different dynamic performance aims, with the emphasis on weight reduction to promote nimble handling, the MX-5 and RX-8 share no major parts, nor do they share the same platform. The unibody, chassis, powertrain, interior, and electrical system for each car have been developed independently to fulfill two well-defined, distinctive missions.

Technology Sharing

The RX-8 and MX-5 share several technologies. For example, Mazda Advanced Impact Distribution and Absorption System (MAIDAS) technology used in all products yields a light but strong body structure capable of efficiently absorbing crash forces, thereby enhancing occupant protection. Friction spot welding perfected by Mazda engineers joins aluminum components that comprise the RX-8's door assemblies and the aluminum and steel parts that comprise the MX-5's light, stiff decklid. There are other instances where Mazda-engineered expertise is applicable to both sports cars. Mazda calls this strategy Technology Sharing.

Architecture Sharing

The new MX-5 and RX-8 are also built on the same production line at Mazda's Ujina No.1 factory. The line is flexible enough to handle manufacturing of several models, from the Mazda2 to the MPV class, offering greater efficiency as regards production and equipment investment.

Body framing jigs for the RX-8 were configured with a sliding section that accommodates other models with different wheelbases. By sharing a few locating points and adjusting this sliding section, the MX-5 unibody is able to share the RX-8's framing tools. Welding robots and other tools are programmed utilizing extensive computer control technologies to distinguish the differences and automatically apply the appropriate welding procedure for each model. Thus, the MX-5 can share the same assembly line with the RX-8 in spite of the MX-5's markedly different wheelbase, width, and track dimensions. Mazda calls this strategy Architecture Sharing. While some manufacturers use similar terms when describing shared underbody parts, there is no sheet-metal or "platform" sharing between the RX-8 and the MX-5.

Architecture Sharing also applies in other design areas. For example, a forged aluminum suspension member from an RX-8 resembles one from the MX-5 because both parts came from the same supplier and both were engineered using the same design philosophy.

So while the MX-5 and the RX-8 do share some technology and certain architectural details in aid of manufacturing efficiency, they are not built on the same platform and do not share any significant parts.

CHAPTER 5
CRAFTSMANSHIP AND CREATURE COMFORTS

To maximize the immediacy of the driver-vehicle interface, in addition to static attributes, the MX-5 development team placed special emphasis on dynamic aspects of craftsmanship.

Dynamic Craftsmanship

The fit of the driver to the car and its controls is a critical aspect of any enjoyable lightweight sports car. State of the art analysis tools were employed to assure that all drivers ranging from 150 cm (4 ft, 11 in) to 186 cm (6 ft, 1 in) in stature could realize a comfortable seating position.

Legroom and headroom are increased by 10 mm (0.4 in) and 17 mm (0.7 in) respectively to accommodate 95-percentile US males. Fore-and-aft adjustment is increased by 50 mm (2.0 in) over the previous MX-5. Another improvement is the addition of a steering wheel adjuster offering 32 mm (1.3 in) of vertical movement.

To perfect the location and orientation angle of the steering wheel, a driving simulator was employed. Eight sensors attached to the driver's arms facilitated analysis of myoelectric activity during routine control movements. This information enabled engineers to fine-tune the steering to achieve a comfortable steering effort. Other measurements of manipulative ellipsoid made with the assistance of Hiroshima University faculty members allowed plotting operating-force ellipsoids quantifying the force and motion needed to activate the shift lever. This body of knowledge was instrumental in finding the driver's "sweet spot," or in other words, the point where the minimum effort and the least amount of motion was needed to turn the steering wheel and move the shift lever.

Further ergonomic studies revealed that the height difference between the driver's shoulder and the top of the shift knob has a major influence over the amount of force that can be comfortably applied. This resulted in positioning the MX-5 shift lever fairly high to minimize the magnitude of grip required at the side of the knob. The knob was shaped to yield a uniform pressure no matter how the knob is gripped.

To improve heel-and-toe operation of the brake and throttle, the height difference between those two pedals has been reduced by 5 mm (0.2 in) and pad surfaces are larger. The dead pedal has been moved a bit closer to the clutch pedal to make its position more comfortable.

By polling customers, the development team learned that the surface feel, grip of controls, and their shape were critically important parameters. Leather wrapping the steering wheel helps reduce its slipperiness. Increasing the friction between the hands and the wheel significantly reduces the necessary grip force. But too much friction lowers the grip needed to the point the wheel feels sticky and over-sensitive to hand motion. So the leather used for the MX-5's wheel and its exterior coating were very carefully selected. A glove equipped with pressure sensors revealed that most of the grip

for steering wheel movements comes from palm and middle-finger pressure. This study led to a thicker layer of soft urethane padding and an egg-shaped cross- section for the rim, imparting a natural feel that is valued feature of Mazda sports cars. Simple toggle switches were added for cruise-control and audio-system functions.

The MX-5's bucket seats are configured with spring-type cushion suspension to insulate the occupants from road vibration, reinforcements to make the upper and lower structure of the seat sufficiently stiff, and support springs firm enough to resist movement of the occupant's center of gravity during cornering, braking, and accelerating. Compared to the second-generation MX-5, the vertical movement of the center of pressure against the seat back is cut in half. While the driver's shoulder is free to move without restraint, the seat back provides ample under-arm torso support. The front of the seat is soft enough to permit easy pedal operation and firm enough for good thigh support. The seat-belt guide imparts a sense of oneness between the driver and car by its ease of use.

Strides in outward visibility were achieved by positioning the windshield 3-degrees more upright and by locating their bases 90 mm (3.5 in) closer to the occupants. This results in forward visibility, when looking towards the near-side windshield pillar, that's 4 degrees wider than before. Which substantially aids locating the apex of the curve during cornering maneuvers.

Research at Mazda's Yokohama Technical Center allowed coordination of engine sounds with the MX-5's acceleration rate. A five-axis system—using linear, harmonic, calm, quiet, and deep indexes—was created for an evaluation panel to log their auditory impressions. Goals established were enhancing harmonic characteristics through intake and exhaust tuning, emphasizing the calm dimension by reducing high-frequency engine noise, swelling the linear aspect with reduced rumble noise, and minimizing the boom and harsh sounds at low rpm. An ArtemiS software package from HEAD acoustic allowed the panel to compare audio data by listening through head phones. A map of the car's "voice" was created by plotting engine rpm (horizontal axis) versus sound frequency (vertical axis) with color traces indicating the intensity of the sound.

As part of this examination, the MX-5's engines were tuned and engineered to deliver sounds consistent with Jinba Ittai priorities the way a conductor directs an orchestra performing a complex musical score. The three distinct sources of noise - mechanical engine components, the intake system, and the exhaust system - were treated like the brass, woodwind, and percussion sections of an orchestra to create a harmonious voice which greatly enhances both the MX-5's vitality and its car-to-driver (rider and horse) bond.

From idle to 5,000 rpm, the tuned lengths of the intake manifold runners play the dominant melody. Since the mechanical ruckus of the engine is subdued by a very stiff cylinder block and a well supported crankshaft, the harmony of the equal-length runners sings sweetly with an intensity roughly proportional to the throttle opening. Exhaust tones supplement the intake refrain below 3,000 rpm, after which the car is moving forward quickly enough that the exhaust contributions to the sound track are lost to the wind.

The MX-5's Variable Induction System (VIS) is another key orchestral instrument. A valve in the intake manifold remains closed between 3,250 and 5,000 rpm to maximize torque and to maintain the equal-runner-length harmony mentioned above. Above 5,000 rpm, the valve opens to shorten runner length, thereby maximizing the engine's output all the way to the 6,700 rpm redline. In this condition, intake runners are UNEQUAL length which generates a throaty rumble sound with the throttle floored and the tachometer climbing.

To enrich these engine notes and to add to the MX-5's aggressive-sounding character, one wall of the intake manifold plenum chamber is tuned to resonate at 500 Hz much like tympani filling in the orchestra's low tones.

Static Craftsmanship

The latest advancements in manufacturing technology facilitate many high-quality, finely crafted static attributes. Front bumper guards are injection molded using glass-reinforced plastic instead of steel to minimize the space required for this component. That, in turn, left room for a dramatic headlamp design and a specially curved hood opening. The guard is fitted by ultrasonic welding instead of by conventional screw attachments.

The windshield frame has a one-piece design that increases strength while producing a smooth, flowing outer surface. Sun visors nest neatly in recesses formed into the horizontal portion of the frame.

To minimize or eliminate interior gaps, the passenger-side air bag cover is seamless and a tight interface is provided between the center stack and console.

Door armrests are covered with a soft rubber material. The rigidity of the door structure was tuned to provide a pleasant closing sound.

Amber gauge illumination sets the tone for interior illumination. Audio controls, climate controls, steering-wheel-mounted switches, the Sport mode shift gate, and power window switches are all illuminated with light of the same color and intensity. Black dials with a white needle improve visibility, and the needles jump when the ignition is switched on, giving a lively feel to starting up. Switch and vent register vane motion has been tuned for a high-quality sensation. Some interior trim has a matte aluminum finish for a very refined look. Many plastic interior parts have textured surfaces (when viewed under a microscope) to disperse incident light, yielding a higher quality appearance from all angles during various lighting conditions.

The new Z-fold soft top is easy to raise and lower from the driver's seat by means of a single, central latch-handle. (Dual latch handles were previously fitted.) Hidden assist springs preserve a neat appearance. The top structure is a weight-savings design requiring no cover in the lowered position because support bows are hidden from sight. A roof drip molding above the side windows and weather-strips with a minimum number of joints help keep rain water from infiltrating the interior. High-speed vibration of the top is discouraged by a new reinforcement at the top of the rigid glass rear window opening. The soft top is available made of cloth or vinyl.

For a cleaner and sleeker appearance, the rear window of the Sheet Molding Compound (SMC) hard top meets the deck surface and no molding is used between the glass and hard top. Rear latches that hold the top to the body are a lighter-sectioned, more elegant design. The inside of this top has a molded liner and seals that resemble the trim of a closed coupe. A safety lever is provided at each inside latch position to signal when the latch is fully engaged.

An engine cover hides unsightly hoses from view, suppresses injector noise, and provides a neatly integrated underhood appearance.

Special visual touches are the radically rounded hood opening, oval exterior motif, heavy-thread upholstery stitching, and well designed instruments that twitch slightly when the ignition key is turned.

Deep-Seated Comfort

To make the MX-5 as pleasurable as possible and enjoyable to drive on a daily basis, comfort-related details received special attention.

Wind in the hair is one thing but cockpit turbulence and buffeting isn't fun on long drives. Small quarter windows block drafts between the windshield pillars and door mirrors into the cockpit. A newly designed aero board located between the seat back hoops is taller than before and perforated to slow down reverse-flow air that rushes into the cockpit. Mesh construction helps to reduce weight.

Even though the climate control system is smaller than before to facilitate a more rearward engine location, a highly efficient design allows it to do a better job maintaining cabin comfort with the top down or up. The addition of two HVAC registers helps direct air flow towards the waists and thighs. A total of seven climate-control modes are provided to cover every possible circumstance. In the new vent-waist mode, cool air can be directed not only towards the upper body but also towards the thighs, to alleviate heat from the sun on summer days with the top down. And in the new footwaist mode, warm air is circulated through the foot wells and the waist-level outlets to keep lower body areas warm in winter, greatly extending the top-down season.

The MX-5 includes an AM/FM radio plus CD player with four speakers and two tweeters on the GX and GS models. The GT comes with a Bose® audio system that includes an AM/FM radio plus CD player with five speakers and two tweeters.

Rear speakers are mounted in the rear trim next to the top-inboard corners of the seats for optimum audio performance, especially with the top down (availability depends on the model). Full range and tweeter speakers are mounted in the door panels. Bose premium systems also have a full-range speaker mounted atop the dash to enhance audio imaging.

Equalization can be tailored to open or closed driving thanks to a switch that informs the head unit of the car's configuration. A cabin-mounted microphone allows a new Bose® AudioPilot® system to compensate for ambient noise. The sound field and phase characteristics are prioritized slightly in the driver's favor. The standard system has a vehicle-speed-sensitive volume switching feature that is operated manually. For more information, see Chapter 8: Bose® sound system.

CHAPTER 6
SAFETY, SECURITY, ENVIRONMENTAL AWARENESS

The design of the third-generation MX-5 embodies a high level of active and passive safety. Drivers are helped to avoid a collision by simply exploiting the MX-5's outstanding ability to steer or brake out of harm's way. Dynamic stability (yaw) control is now available as an option or standard in most markets. Four-wheel anti-lock braking system is also available as standard or as an option.

Windshield pillars that are more widely separated and moved slightly rearward afford an enhanced view of the road ahead. Sun visors are positioned high enough in the stowed position not to block the driver's view.

Passive Safety Features

The new MX-5's rigid unibody design uses the Mazda Advanced Impact Distribution and Absorption system to meet and exceed government collision standards. Occupant protection from injury as a result of front, side, and rear impacts from various angles is provided and its safety performance is excellent. The windshield pillars and front frame use high-strength steel sheet and ultrahigh-strength steel sheet to further reinforce body stiffness.

Front collision performance: The compact body is designed to withstand both full wrap and offset collisions. To efficiently absorbs collision energy in the short crushable zone, the front frame employs octagonal section ultra-high-strength steel sheet, increasing the energy absorption volume while also contributing to weight loss. Additionally, to suppress cabin deformation in an offset collision, the energy impacting on the front frame is distributed in three directions into a three-pronged structure in front of the cabin.

Side impact performance: Body floor cross-members are elongated and door impact bars are optimized in a collision energy absorption and distribution structure, minimizing deformation of the car body. In addition to suppressing body deformation, impact absorbing structures in the door trim and a new side air bag system (availability differs with the markets) cushion impacts to occupants.

Driver and passenger seat belt restraints are equipped with locking retractors with automatic pretensioners that tighten the belt immediately after a moderate frontal collision and load limiters that meter out some belt in stages to reduce the load on the occupant.

The new steering-wheel-mounted supplemental restraint system (SRS) air bag emerges from its storage container in the shape of a doughnut but quickly swells to surround the center horn button to guard the driver's head and torso from impact forces.

The passenger-side air bag has a seat-mounted passenger weight detector to change the air bag function according to the occupant's weight. An off switch disables this function when desired, such as when a small passenger in rear-facing safety seat is being transported.

Newly developed seat-mounted side air bags are standard on the GT model. An inflator inflates two chambers in each bag to provide both additional torso and head protection from side-collision injury. The firmness engineered for the larger head air bag is purposely higher than that specified for the smaller torso restraint. A check valve located between the two volumes helps keep the head restraint inflated for a longer period of time.

Instead of collapsing along its axis, the steering column moves in a horizontal direction when loaded by the driver's weight to minimize the likelihood of head and chest injury. Crashable brake pedals are prevented from crushing back into the feet so they're less likely to inflict lower-leg injuries. Seats and headrests help resist neck injuries caused by low-speed rear impacts.

A special Shock Cone inner hood panel—technology introduced on Mazda's RX-8 rotary-powered flagship—greatly reduces the chance of pedestrian injury by safely absorbing head-impact energy. Front strut towers are braced to the cowl instead of to each other to provide extra space for energy dissipation. In addition, there is a large volume of energy absorbing material behind the front bumper to lower the risk of knee injury during a pedestrian impact.

Thanks to this major emphasis on active, passive, and pedestrian protection, the new MX-5 is one of the most safety conscious sports cars on the market.

Security Features

To minimize the chance of theft, the MX-5 has a standard immobilizer system to prevent starting the engine without the proper ignition key. The key contains a transponder which communicates with the lock cylinder to signal a controller that it's OK to energize cranking, ignition, and fuel delivery systems.

On the GT model, an Intelligent Key System permits starting and stopping the engine, unlocking the steering wheel, locking and unlocking the doors and unlocking the decklid simply by carrying the card-type key along in a pocket. Buttons are also provided to lock and unlock the doors and to unlock the decklid from a remote location.

The GT model is also equipped with an anti-theft system that triggers an alarm if the vehicle is tampered with. A backup battery keeps the alarm active when the main battery is disconnected.

As a security measure for when the top is off, the trunk is equipped with a canceling mechanism. When the switch is off, the trunk lock cannot be released unless the keyless entry system or master key is operated.

Environmental Measures

The MZR family engines powering MX-5s comply with stringent Euro 4, US LEVII, Japanese ULEV and Australian Stage 3 emissions standards.

Use of recyclable materials—such as aluminum and steel sheet metal—allows the MX-5 to comply with European standards that specify a recyclability potential of at least 85-percent. In accordance with the international 22628 standard, these parts contribute to a 95-percent ratio of recoverable and recyclable materials. Identification marks on plastic parts facilitate their reuse. Mudguards are made of material from scrapped and shredded bumpers. Working hard to minimize use of environmentally hazardous substances, Mazda has almost totally eliminated lead, hexavalent chromium, mercury, and cadmium from its products; use of polyvinyl chloride has diminished 50-percent since 1998. All Mazda development and production operations in Japan are ISO 14001-certified.

The MX-5 intake and exhaust systems are engineered to comply with the world's drive-by noise standards.

CHAPTER 7
MESSAGE FROM KEY MAZDA MX-5 TEAM MEMBERS

In designing the new MX-5, the design team was charged with the task of creating a unique design with clean and simple lines that would be instantly recognizable as the new MX-5 even when viewed from a distance. To merge expressions of the “simple beauty of the lightweight sports car” and “the immediacy of refined functionality” at a high level demanded meticulous attention to each and every part and shape of the vehicle. The result of these efforts pays off in a car that gives irresistible pleasure in the way it looks, feels and drives. That’s the new MX-5 design.

Yasushi Nakamuta
Chief Designer
Design Strategic Studio

We set the goal of achieving Jinba Ittai. To do this demanded thorough research and improvement right down to the fine details, in a way that was consistent with the saying, “With accumulation, even dust becomes a mountain”. The development team returned once more to the original MX-5 to conduct extensive research into the car’s details, in a determined effort to make improvements. For instance, we were tasked with what was termed the “gram strategy”, which involved looking for opportunities of trimming vehicle weight by as little as one gram wherever possible. This was the job of a lifetime for us, and we kept our goal in mind at all times as we worked towards achieving the masterwork that is the new MX-5.

Nobuhiro Yamamoto
Deputy Program Manager
Vehicle Engineering Promotion Department

Developing and building in engine torque characteristics, super response, sporty sound and gearshift feel involved us in activities that were not unlike being able to see our landing spot but at the same time being unable to skillfully fly our glider into a successful landing. But the powertrain development team worked assiduously to achieve a particularly dynamic and linear performance feel as well as a satisfying engine sound from low to high revs. And when all these attributes were in place, and we experienced the Jinba Ittai feel, we knew we had landed. The third-generation MX-5 certainly makes you feel all these things. It’s a car that delivers satisfaction.

Tetsuo Fujitomi
Deputy Program Manager
Powertrain Development Promotion Department

CHAPTER 8
BOSE SOUND SYSTEM

Adding to that unique roadster experience is an available Bose® sound system. Like the MX-5, the Bose system is also engineered specifically for open-air driving. Advanced design and innovative technology enable the system to automatically adjust the sound for the acoustics of a closed cockpit or a full-out, drop-top ride.

System Highlights

Adaptive digital equalization – Raising or lowering the top completely alters the sonic characteristics of the cockpit. The Bose sound system has been equalized for top-up or top-down driving. As soon as the top is raised or lowered, Bose adaptive digital equalization automatically selects the proper EQ.

AudioPilot® noise compensation technology – This patented innovation automatically and continuously reduces the effects of outside noise. It is more advanced than speed-dependent volume control – which simply adjusts the volume in relation to vehicle speed. The AudioPilot® system also responds to noise unrelated to speed, like an open cockpit or changing road surfaces. This unique capability allows it to work with the adaptive digital equalization to help reduce the unwanted effects of open-air driving.

High-performance, lighter-weight system – Light but powerful neodymium iron boron magnets in all speakers help provide concert-like sound reproduction and lighter system weight for better vehicle performance.

Advanced Technologies

The patented Nd® woofer –This Bose innovation uses a powerful neodymium iron boron magnet and innovative design to add depth to the music while fitting unobtrusively in the doors and preserving space inside the cockpit.

Digital technology – This advancement delivers more lifelike reproduction, much as a CD typically gives clearer music reproduction than a comparable vinyl record.

Customized equalization – Engineered specifically for the MX-5, this high-precision digital signal processing circuitry delivers a natural tonal timbre. It balances the output at audible frequencies so passengers can enjoy music with clarity and power. This digital system provides four channels of complex equalization delivering smoother and more lifelike sound to each speaker.

Custom signal processing – The digital Bose sound system in the MX-5 makes automatic adjustments that allow music to be heard with fullness and detail; speech to sound more natural; and for the system to approach live performance levels without sounding distorted.

Bose System Engineering

Clean sheet design – A unique approach invented by Bose and refined over 20 years. It differs from conventional solutions that simply add components after the vehicle is designed. Instead, cabin acoustics are carefully measured and the sound system is custom-engineered specifically for the new MX-5.

Advanced cabin analysis – More than a thousand different factors are studied, from listener seating locations to the acoustical effect of the seat material. Nearly every decision, from speaker placement to equalization, is based on this information. As a result, listeners hear music with more of the emotion of a live performance.



MX-5

By combining a host of new ideas and technologies with the finest aspects of the original MX-5, Mazda has given the classic lightweight sports car a fresh lease on life for the 21st century.

As the purest expression of the Zoom-Zoom spirit, the MX-5 is Mazda's latest and best gift to its growing worldwide constituency of driving enthusiasts.

DATA
History of the Mazda MX-5

1983 ~		Mazda begins study of lightweight sports car production.
1986	February	Starts project aimed at volume production.
1987	September	Design finalized.
1989	February	Mazda MX-5 Miata makes its world debut at the Chicago Auto Show.
	May	US sales begin.
	September	Sold as Eunos Roadster in Japan.
	October	Sales begin in Australia.
1990	February	Sales begin in Europe (U.K. and Holland).
1993	July	Undergoes minor change. Car improved by replacing previous 1.6-liter engine with 1.8-liter version.
1997	October	Second-generation Mazda MX-5 Miata unveiled at Tokyo Motor Show.
1998	December	Limited edition Mazda MX-5 released to commemorate ten years in production. Special limited edition car with world-class specifications: total of 7,500 units manufactured for worldwide sale (500 units for Japan, 7,000 units for the three markets comprised of North America, Europe and Australia).
2000	May	Mazda MX-5 Miata enters the Guinness Book of World Records as the world's best-selling two-seater open sports car.
	July	Second-generation Mazda MX-5 Miata undergoes minor change. In addition to interior and exterior changes, the 1.8-liter engine gets a power boost, and body stiffness and other improvements add up to a greatly upgraded version.
2005	March	Third-generation Mazda MX-5 unveiled at the Geneva International Motor Show.
	March	Third-generation Mazda MX-5 debuts in commemorative limited edition format (Mazda MX-5 3rd Generation Limited) at the New York International Auto Show.
	April	The Guinness Book of World Records updated the number of units produced to 700,000.

Production and Sales Results

Mazda MX-5 Production Results	
CY	Production (Units)
1988	12
1989	45,266
1990	95,640
1991	63,434
1992	52,712
1993	44,743
1994	39,623
1995	31,886
1996	33,610
1997	27,037
1998	58,682
1999	44,851
2000	47,496
2001	38,870
2002	40,754
2003	30,106
2004	24,232
2005 (1-4)	2,667
Cumulative	721,621

Mazda MX-5 Sales Results					
CY	North America	Canada only	Europe	Japan	Australia
1989	25,879	2827	-	9,307	621
1990	39,850	3906	9,267	25,226	1,446
1991	34,196	2956	14,050	22,594	746
1992	27,241	2277	6,631	18,657	502
1993	23,089	1501	4,824	16,789	453
1994	22,573	1173	5,019	10,830	404
1995	21,108	934	7,176	7,178	197
1996	18,966	558	9,585	4,413	241
1997	17,812	594	10,480	3,537	206
1998	20,890	1047	16,831	10,172	1,310
1999	19,025	1198	21,128	4,952	1,354
2000	19,550	1,328	19,264	4,644	1,038
2001	17,757	1,271	16,366	4,211	924
2002	15,622	1,230	19,663	2,934	698
2003	11,999	1,079	18,931	1,520	540
2004	10,502	1,146	13,900	1,646	483
2005 (1-4)	2,728	292	3,040	404	127
Cumulative	348,787	25,317	196,155	149,014	11,290

New MX-5 Specifications

Engine

Type	Inline 4-cylinder
Valve gear	DOHC - 16 valve with VVT (MZR)
Displacement	1999 cc
Bore and Stroke	87.5 X 83.1
Compression Ratio	10.8 : 1
Horsepower SAE net	170 @ 6700 rpm (166 AT)
Torque, SAE net lb.-ft.	140 @ 5000 rpm
Fuel System	Multi-port Electronic Fuel Injection (EFI)
Recommended Fuel	Premium (unleaded)

Drivetrain

Type	Front engine/rear-wheel drive
Transmission	5-speed manual (GX) 6-speed manual (GS and GT) Optional: 6-speed electronically controlled automatic with overdrive and lock-up torque converter (GX & GT) and paddle shifters (GT)

Gear ratios:	**5 MT**	**6MT**	**6AT**
1st	3.136	3.815	3.538
2nd	1.888	2.260	2.060
3rd	1.330	1.640	1.404
4th	1.000	1.177	1.000
5th	0.814	1.000	0.713
6th	—	0.832	0.582
Reverse	3.758	3.603	3.168
Final Drive	4.100	4.100	4.100
Clutch type	Single dry plate (diaphragm spring)		

Suspension

Frame	Unit body (Monocoque), Power Plant Frame (PPF)
Suspension	Front: Fully independent double wishbone with coil springs Rear: Multi-link with coil springs Front and rear stabilizer bars

New MX-5 Specifications

Chassis

Steering	Rack-and-Pinion type with engine rpm sensing variable power assist
Steering Ratio	15.0:1
Steering Wheel Turns	2.7 (lock to lock)
Min. turning Circle	9.4 m (curb to curb)
Brakes	Power-assisted 4-wheel disc brakes with diagonal hydraulic circuits Anti-lock Braking System (ABS) (GS & GT models)
Wheels	16” Alloy Wheels; 17” Alloy Wheels (GS & GT Models)
Tires	205/50R16 205/45R17 (GS & GT Models)
Curb Weight	5MT — 1,108 kg (w/o A/C) 5MT — 1,123 kg (w/ A/C) 6MT — 1,119 kg (w/o A/C) 6MT — 1134 kg (w/ A/C) 6AT — 1,132 kg (w/o A/C) 6AT — 1147 kg (w/ A/C)

Electrical System

Battery	12 Volt - 32 amp
Alternator	12 Volt - 100 amp
Ignition System	Distributorless Ignition

Capacities

Seating	2
Engine Oil Capacity	4.6L
Coolant Capacity	7.1L
Washer Fluid Tank	3.5L
Fuel Tank	48L

New MX-5 Specifications

External Dimensions (mm)

Wheelbase	2,330
Track (Fr/Rr)	1,490/1,495
Length	3,990
Width	1,720
Height	1,245
Ground Clearance	118 (laden)

Internal Dimensions

Headroom	950 mm
Legroom	1,096 mm
Shoulder Room	1,352 mm
Hip Room	1,286 mm
VDA Cargo Volume	150L

Fuel Economy Ratings (Transport Canada)

	City	Highway
5-Speed Manual	9.5L/100km	7.3L/100km
6-Speed Manual	9.7L/100km	7.2L/100km
6-Speed Automatic	10.3L/100km	7.1L/100km

Estimated Performance Data

Acceleration MT (0 - 100 km/h: sec)	5MT - 8.0
	6MT - 7.5
	6AT - N/A
Top Speed MT (km/h)	5MT - 205
	6MT - 206
	6AT - 191
Weight Distribution % (fr/rr)	52 / 48

Features

S = Standard O = Optional

Engineering Features	GX	GS	GT
2.0L DOHC 16-valve 4-cylinder with VVT (MZR)	S	S	S
5-speed manual transmission	S	--	--
6-speed manual transmission	--	S	S
6-speed electronically controlled automatic transmission with overdrive	O	--	--
6-speed electronically controlled automatic transmission with overdrive and paddle shifters	--	--	O
Rack-and-pinion steering with engine-rpm-sensing variable power assist	S	S	S
Brakes, power-assisted 4-wheel ventilated front / solid rear disc	S	S	S
Anti-lock brake system (ABS)	--	S	S
Front engine / Rear-wheel drive	S	S	S
Front Double wishbone suspension with aluminum arms, mono tube dampers	S	S	S
Rear Multi-Link suspension with aluminum baring support, mono tube dampers	S	S	S
Front and rear stabilizer bars	S	S	S
Aluminum Power Plant Frame (PPF)	S	S	S
Limited-Slip Differential (LSD)	--	S	--
Dynamic Stability Control (DSC) with traction control	--	S	--
Strut tower bar	--	S	S
Sport suspension including Bilstein Shocks	--	S	--

Exterior Features			
16-inch aluminum alloy wheels	S	--	--
205/50R16 performance radial tires	S	--	--
17-inch aluminum alloy wheels	--	S	S
205/45R17 performance radial tires	--	S	S
Black vinyl soft-folding convertible top	S	S	--

Features

S = Standard O = Optional

Exterior Features	GX	GS	GT
Beige or black cloth convertible top	--	--	S
Detachable hardtop attachments	S	S	S
Detachable hardtop, body colour	O	O	O
Windshield, solar-control/tinted (green)	S	S	S
Rear glass window with electric defogger	S	S	S
Power colour-keyed door mirrors	S	S	S
Wipers, 2-speed fixed intermittent	S	S	S
Headlights - Halogen	S	S	-
Headlights - Xenon (HID)	--	--	S
Fog lights	S	S	S
Seat-back style bars	S	S	S
Antenna, rear fender mounted	S	S	S
Dual exhaust outlets - silver coloured tips	S	S	S
Interior Features: Comfort and Convenience			
Air conditioning	O	O	S
AM/FM radio plus CD player w/4 speakers and 2 tweeters	S	S	--
BOSE audio system (includes AM/FM CD w/ 7 speakers - including 2 tweeters) with AudioPilot noise compensation technology	--	--	S
Windblocker - mesh aero board	S	S	S
Cruise control	S	S	S
Leather-wrapped 3-spoke steering wheel	S	S	S
Leather-wrapped shift knob	S	S	S
Steering wheel mounted audio controls	S	S	S
Tilt-Steering	S	S	S
Silver-finish interior trim including gauge rings, air-vent bezels, door inner handles, shift-plate bezel and steering wheel	S	S	S
Power door locks	S	S	S

Features

S = Standard O = Optional

Interior Features: Comfort and Convenience	GX	GS	GT
Remote keyless entry system with retractable key, and panic alarm (includes two transmitters)	S	S	--
Intelligent Key System (keyless entry and start)	--	--	S
Internal trunk and fuel door releases	S	S	S
Power windows with driver's one-touch down feature	S	S	S
Heater/defroster with multiple-speed fan	S	S	S
Needle punch carpeting	S	S	S
Floor carpet mats	S	S	S
Trunk room mat, rear and side trim	S	S	S
Trunk light	S	S	S
12-V power outlet	S	S	S
Day/night rearview mirror	S	S	S
Courtesy light on windshield header	S	S	S
Integrated type sunvisors with vanity mirrors	S	S	S
Interior Features: Seating and Trim			
Bucket seats with reclining and forward/back slide feature	S	S	S
Integrated headrests	S	S	S
Black cloth upholstery	S	S	--
Black or saddle brown leather interior	--	--	S
Heated Seats	--	--	S
Map pocket on driver's side seatback	S	S	S
Interior Features: Safety and Security			
Burglar alarm	--	--	S
Dual front airbags	S	S	S
Engine immobilizer theft-deterrent system	S	S	S
Side airbags	--	--	S
Side impact door beams	S	S	S
Seatbelt pretensioners with force limiter	S	S	S
ISOFIX child seat anchors	S	S	S
Tire puncture repair kit	S	S	S

Features

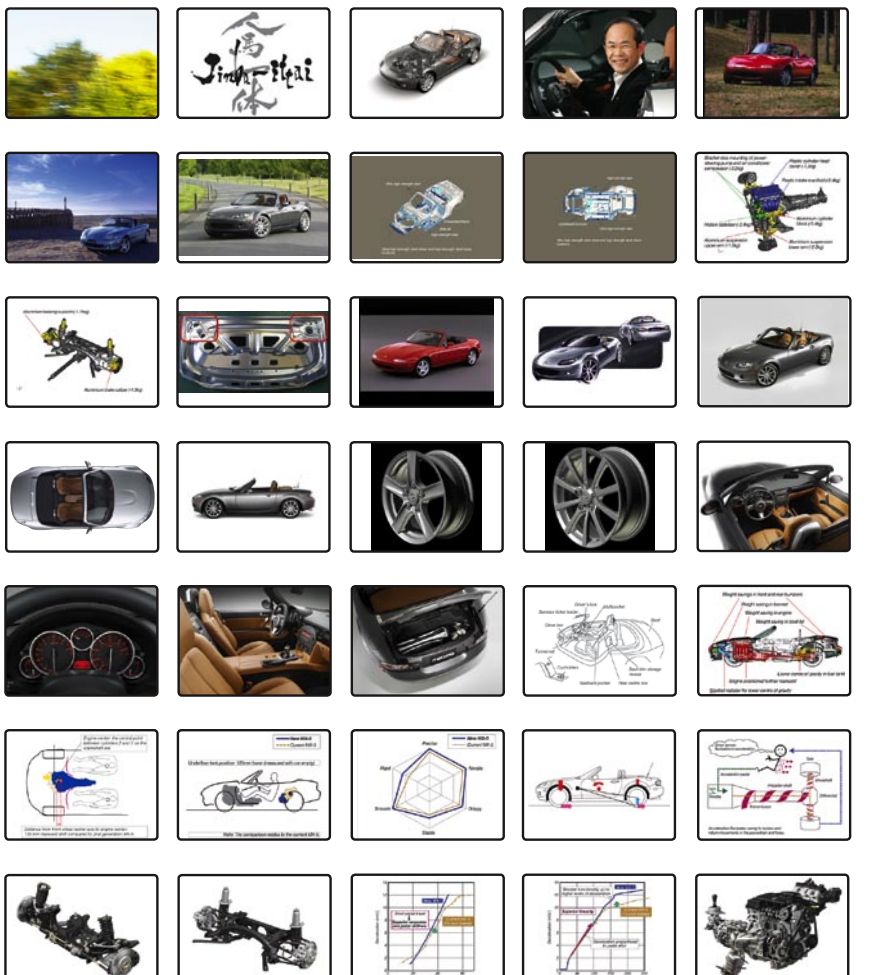
S = Standard O = Optional

Interior Features: Storage	GX	GS	GT
Trunk room storage box	S	S	S
Lockable glove compartment with 5.7L capacity	S	S	S
Passenger floor tunnel net pocket	--	S	S
Side door pockets with bottle holders	S	S	S
Rear centre storage compartment	S	S	S
Back trim storage recess behind each seat	S	S	S
Dual cup holders	S	S	S
Coin holder	S	S	S

Interior Features: Instrument Panel			
Resettable twin trip odometers	S	S	S
Full Instrumentation including, tachometer, coolant temperature gauge, oil pressure & fuel indicators	S	S	S
Low fuel warning lamp	S	S	S
Gauges, black with white lettering & red nighttime illumination coated with low reflection film	S	S	S

S = Standard O = Optional

Figures and Vehicle Photography



Figures and Vehicle Photography

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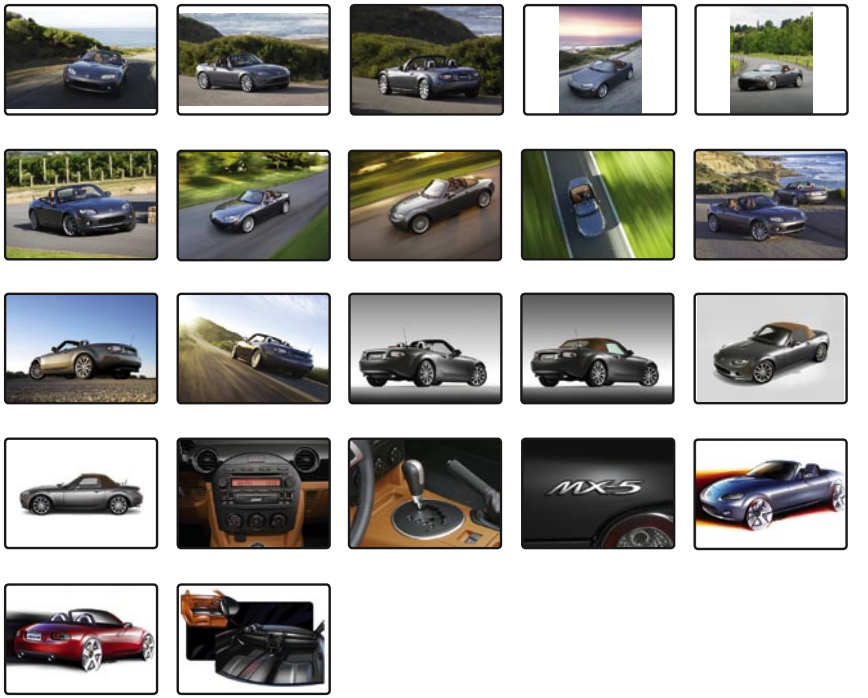

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