

# New Technologies Developed for the New COLT for Europe

Norifumi MIKAMI\* Kunio TAKAOKA\* Shiro MORITA\* Ken KATAOKA\*  
Masahiro KANEDA\* Masahiro INOUE\* Akihiro HARADA\*



Golden steering wheel award in 2004

## Abstract

The version of the Mitsubishi COLT for Europe came into being through development and production processes that were not adopted with the version for Japan. The vehicle was jointly developed with DaimlerChrysler (DC) and smart, so the work performed to realize these processes provided priceless experience in terms of both technological cooperation and communication.

Notably, Mitsubishi Motor R&D of Europe (in Helmond, the Netherlands) formed a crucial base for realizing the special processes through day-to-day technical and communication-related support within a group of partners consisting of the Mitsubishi Motors Car Research and Development Center (in Okazaki, Japan), NedCar, smart, MDC-Power, DC, and suppliers.

The special processes are behind the quality that has earned the COLT the German 'Golden Steering Wheel' and other European accolades. This report describes their key technological and communication-related aspects. It is hoped that the information will be useful when further new development and production processes are devised inside and outside Japan.

**Key words:** High Strength, System Supplier, Module, Network, Integration, Joint Development, Communication

## 1. Hot-stamped bumper beam

### 1.1 Technology overview

Hot stamping is a production method, aimed at lightness, whereby high-strength sheet steel, which cannot easily be formed using the conventional pressing method, is heated to a high temperature to realize formability and concomitant design freedom. A further benefit is that workpieces can be stronger after being hot-stamped than before (Fig. 1).

With the new COLT for Europe, this specialized method was used to satisfy conflicting demands for impact resistance (essential for compliance with requirements related to Euro NCAP frontal-impact tests and German insurance rates) and lightness.

### 1.2 Key aspects of development

The supplier of the hot-stamped bumper beam, the German company Benteler, played a significant role in the development process. Notably, the supplier, in the process of shape selection for the component, performed repeated CAE analysis not only with respect to the component but also with respect to body deformation.

The technological study for the component began with the assumption that the component's structure would be based on that used with the new COLT for Japan. As the study addressed details of the component, however, additional requirements for shape precision (the component is actually welded onto the body as a front-end crossmember) (Fig. 2) and lightness became apparent. Development was at a stage where even a small change in component shape could have had a significant effect on body deformation.

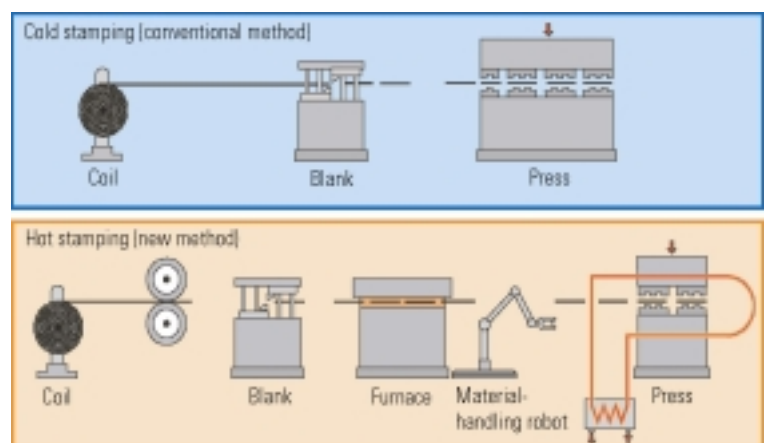


Fig. 1 Hot stamping and cold stamping

\* Helmond Designing Dept., Mitsubishi Motor R&D of Europe (MRDE)



Fig. 2 Hot-stamped bumper beam

Adequately timely selection of the final component shape would not have possible had studies and discussions been conducted among the three relevant parties: the Mitsubishi Motors Car Research and Development Center (in Okazaki, Japan), Mitsubishi Motor R&D of Europe (in Helmond, the Netherlands), and Benteler (in Germany). For this reason, the unprecedented decision was made to resolve the matter by entrusting the task of body-deformation analysis to the supplier. The final result was a component weighing 30 % less than the Japan-specification one and costing (in terms of the euro-yen exchange rate at the time in question) approximately the same.

The structure of the component's body mounting points, which are of primary importance in a collision, is the subject of a German patent application filed jointly by Mitsubishi Motors Corporation (MMC), Benteler, and PDE Automotive (a Benteler group company based in Helmond, the Netherlands).

## 2. Front-end module

### 2.1 Technology overview

The front-end module of the new COLT for Europe incorporates the ① headlamps; ② radiator and related pipes; ③ air-conditioner condenser and related pipes and sensors; ④ hood support rod and lock stay; ⑤ horn; ⑥ airbag sensors; ⑦ air guide panel; and the plastic frame that holds all of these items. It also incorporates mounting structures for other components located in the vicinity (Fig. 3).

The module assembly line (operated by Peguform) is located in the immediate vicinity of the vehicle assembly line at the NedCar plant in Born, the Netherlands, so the cost of transporting the large modules is minimized. Another merit of this arrangement is that information on the fit of headlamps and related parts can be promptly fed back to the staff assembling the modules, meaning that less improving work to achieve high build quality needs to be done on the vehicle assembly line.

### 2.2 Key aspects of development

At the start of development, the makers of the aforementioned parts ① through ⑤ and the supplier of the module (including the plastic frame) were separately selected.

This arrangement contrasted with the usual module concept, whereby the module supplier (tier 1) is first selected and the component suppliers (tier 2) are then selected such that the tier-1 supplier's responsibility

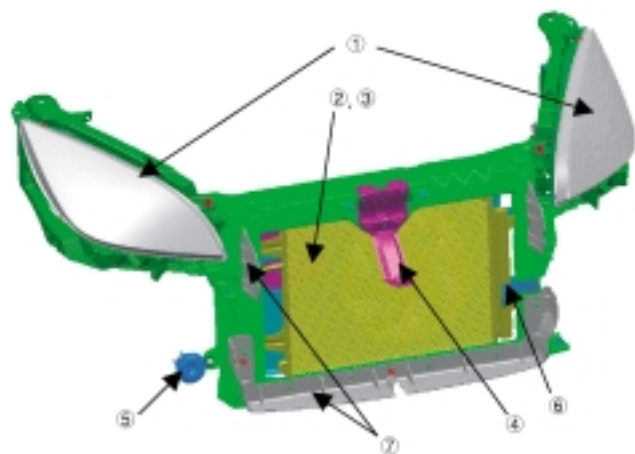


Fig. 3 Front-end module

with respect to the component parts is clear.

As a result, the module and the components were developed separately, meaning that there was a certain amount of inefficiency in terms of time. Also, it is undeniable that there was room for better structural rationalization (integration). (At the time of writing, steps are being taken to improve profitability.)

On the upside, by not entrusting the entire development project to the module supplier MMC gained knowledge about the structural details and material properties of plastic frames.

## 3. Cockpit module

### 3.1 Technology overview

The cockpit module for the new COLT for Europe consists mainly of the following items: ① instrument panel; ② heater blower and air-conditioner unit; ③ cross-car beam; ④ steering column; ⑤ engine & compartment wiring harnesses; ⑥ sheet-metal firewall; ⑦ dash-panel pad; ⑧ pedals; and ⑨ master vacuum brake booster. It is attached to the body by means of the firewall and cross-car beam (Fig. 4).

### 3.2 Key aspects of development

As with the front-end module, the component manufacturers and module supplier were separately selected at the beginning of the development process. The demerits of this approach were as described for the front-end module.

A key merit was that, since specification tests with respect to heat resistance, noise, resonance, and air distribution were performed on a module-unit basis, it was possible to identify and rectify problems quickly. By means of the noise tests, it was possible to realize noise-free operation without measures such as the addition of felt. Further, head-impact testing on the module from development through certification was systematically outsourced to JCI; close development liaison with the certification body enabled the instrument panel to be given a stylish design together with full regulatory compliance.

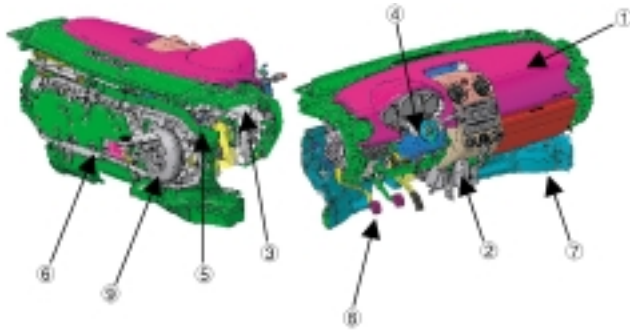


Fig. 4 Cockpit module

## 4. Headlining module

### 4.1 Technology overview

The headlining module consists mainly of the following items: ① headlining; ② room lamp; ③ roof wiring harness; ④ roof pads; and ⑤ rear-seatbelt tongue holder. It is attached to the body by means of the separately attached sunvisors and assist grips (Fig. 5).

Both the cockpit module and the headlining module are assembled on a module line operated by JCI inside the NedCar plant in Born, the Netherlands. For each vehicle, the cockpit module is supplied from the Johnson Controls line to the NedCar line by a conveyor and automatically inserted and mounted in the body by a robot. The headlining module is supplied to the side of the NedCar line and then lifted into the vehicle and mounted by two workers. With this arrangement, the cost of transporting the large modules is minimized, information on the fit of interior parts can be promptly fed back to the staff assembling the modules (meaning that less improving work to achieve high build quality needs to be done on the vehicle assembly line), and function checks on electrical components can be performed on a module-unit basis; quality is concomitantly greatly enhanced.

### 4.2 Key aspects of development

Early in the development process, the sunvisors and assist grips were also included in development of the headlining module. To realize greater ease of handling within the plant (for example, to prevent the headlining from getting bent) with minimal cost, however, the number of components in the module was reduced. As a result, the headlining represents a good balance of quality and cost.

## 5. Vehicle network

### 5.1 Technology overview

The COLT for Europe contains a body-based Local Interconnect Network (LIN) in addition to a Controller Area Network (CAN) of the type earlier adopted by MMC in other vehicle models; the resulting network is more advanced than that of any earlier Mitsubishi vehicle model.

Adoption of such an advanced network made distribution of functions, reduction of cost, and reduction of weight possible. However, the network's complexity

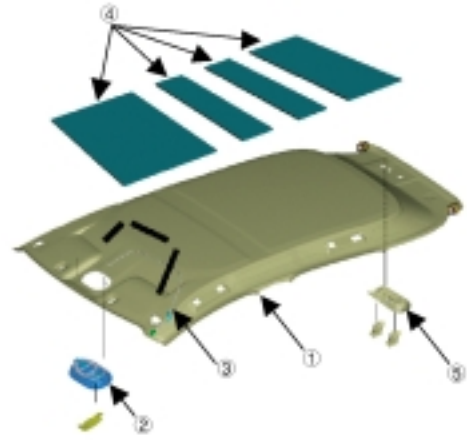


Fig. 5 Headlining module

created the challenge of ensuring reliability.

### 5.2 Key aspects of development

#### (1) Communication between engineers

Since changes in the specifications of communication data has the potential to affect the transmission electronic control unit (ECU) and/or all reception ECUs, coordination between all relevant engineers was essential during development. The COLT's development spanned numerous bases (suppliers outside Japan, suppliers in Japan, smart, and MMC), so the necessary coordination on data specifications was led by Mitsubishi Motor R&D of Europe and PDE Automotive.

#### (2) Evaluation of validity of communication data (bus load, delay time, etc.)

When coordination on data specifications was complete, evaluation of bus load and message delay time was performed by means of simulations. The communication data specification was then changed as necessary and orders were issued to have them implemented in the ECUs. This process made it possible to prevent message delays and other malfunctions from occurring after production of the ECUs.

#### (3) Management of communication data

With the COLT for Europe, smart-unique ECUs, MMC-unique ECUs, and common ECUs were developed in parallel, creating the need for smart and MMC to both revise communication data. Consequently, it was necessary for smart and MMC to manage communication data by means of a shared database. As a solution, the CANdis system developed by DC was adopted at an early stage for consistent data management by smart and MMC.

#### (4) Definition of error-free communication data

To prevent errors in communication, it was essential to define the communication data and implement them in the ECUs. The necessary checks were ultimately performed using actual ECUs.

Further, prior to vehicle fabrication at each stage of development, the suppliers all gathered in single location and together performed bench tests to verify whether data were interpreted in accordance with their definitions, thereby realizing error-free definition of



Photo 1 Bench checks with suppliers

communication data and error-free implementation of the data in the ECUs (Photo 1).

(5) Start and finish of communication (sleep and wake-up)

The network contains ECUs that operate when the ignition switch is turned OFF and ECUs that operate when the ignition switch is turned ON. Unless each ECU starts or stops communicating in accordance with the communication standard when the ignition switch is turned ON or OFF, the battery can go flat and communication errors can occur.

With the COLT for Europe, bench tests were first performed to verify whether communication started and stopped in accordance with the communication standard. Then, network management including erroneous wakeups caused by noise was checked on an actual vehicle. For the checks, a communication tool was used to monitor the actual communication data. From the observations, it was determined whether communication was starting and stopping normally.

With future vehicle models, networks will likely need to be even more advanced and complex. Using the kind of communication techniques and advanced development tools described above, however, efficient development of vehicle networks will be possible.

## 6. Manual-transmission gearshift control

### 6.1 Technology overview

With the COLT for Europe, items ① through ⑥ listed below were adopted by MMC for the first time (Fig. 6).

Each of the items listed below is a supplier's standard part or a standard-design part.

- ① Cable end: Ball-shaped one-touch type (for superior ease of installation)
- ② Rubber boot: Type with breather hole (for low friction)
- ③ Cable socket: Cast-plastic type (for lightness and low cost)
- ④ Cable: Type with band-wound inner wire (for low friction)
- ⑤ Bearing bush: Plastic one-touch type (for superior ease of installation)
- ⑥ Shift knob: One-touch-mounted type (for superior

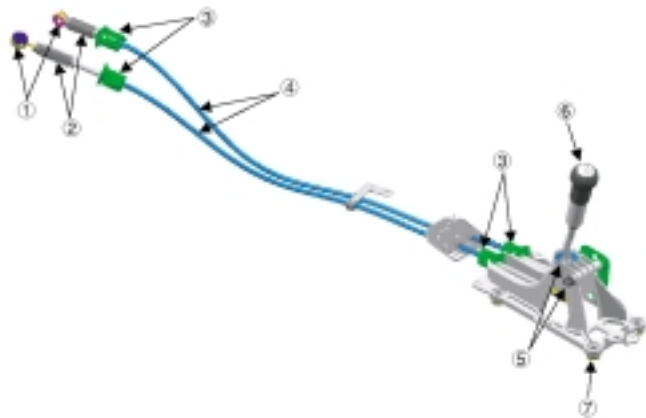


Fig. 6 Manual-transmission gearshift control

ease of installation)

- ⑦ Insulator and distance piece (for superior noise, vibration, and harshness performance)

### 6.2 Key aspects of development

The greatest possible use of suppliers' standard parts realized a low cost. Of course, this approach necessitated the adoption of numerous parts that had never been used by MMC and did not satisfy MMC's evaluation criteria. By collecting information on suppliers' track records in the European market, collecting information on suppliers' design concepts, collecting information on other automakers' use of parts made by suppliers, and having thorough discussions with suppliers about its needs, however, MMC was able to select and adopt appropriate parts. This process required more development time, effort, and patience than making dedicated, new parts would have done. However, the knowledge gained through this process can be expected to form an extremely useful resource for future development efforts. The outcome with the new COLT for Europe was that MMC was able to use standard parts and standard-design parts in all areas except those related to styling and those related to COLT-specific mounting.

## 7. European development of rear torsion axle (joint development with Benteler)

### 7.1 Technology overview

To enable the COLT for Europe to meet the market's expectations for handling stability, new suspension components were jointly developed by MMC and Benteler (Fig. 7).

Major differences from the Japan-specification arrangement are as follows:

- (1) The beam was changed from a U-section open structure to a V-section tubular structure (patented by Benteler).
- (2) A structure in which a stabilizer function is located within the beam was changed to one in which the stabilizer function is integrated into the main body of the beam (patented by Benteler).
- (3) The axle brackets were changed from components that are pressed to components consisting of plates



Fig. 7 Torsion axle: Japan specification vs. Europe specification

welded together.

Revisions (1) and (2) realized rigidity and durability increases over the original arrangement. They also created a degree of freedom for setting of the beam's torsion center (this affects handling stability), making it possible to alter the car's character by design. The new suspension arrangement has the potential to be applied to multiple vehicle models with only small revisions.

Although the COLT for Europe has more or less the same layout as the COLT for Japan, the new suspension arrangement permitted the roll-center height to be made 20 mm higher for better and permitted 5 % lower weight and 10 % higher rigidity.

The new suspension arrangement has started to be adopted in Japan. Since it requires specialized production techniques, however, few prior cases of its adoption existed when COLT development began. In Europe, it has been widely adopted by automakers including Volkswagen.

Revision (3) would have been costly to implement in Japan, but Benteler was able to implement it inexpensively. It was a good example of a solution that was inappropriate in one setting but ideal in another.

The major revisions are as described above. Owing to comprehensive design optimization, however, there are actually few other components that are exactly the same as those in the Japan-specification arrangement.

## 7.2 Key aspects of development

At the beginning of the development program, the Japanese engineers became keenly aware of differences in culture and development methods. Examples are as follows:

- The European engineers would propose structures completely different from those in Mitsubishi drawings.
- The European engineers would not begin production preparations and technology studies before contracts (purchase orders) were complete.
- Differences in language and culture made for poor communication.

It was difficult for the Japanese engineers to correctly convey the intended meaning of 'design requirements'.

And with regard to design drawings, the Japanese engineers realized the huge importance of explaining the reasoning behind proposed structures; the question 'Why?' was asked again and again by supplier-side

engineers throughout the development program.

As mutual understanding deepened, however, the rhythm of joint development improved. The supplier-side engineers gave unreservedly of their effort; no matter how many times target values for performance and durability were changed, for example, the supplier-side engineers were quick to come up with ideas, prove them, produce prototypes, and conduct tests, and they would try multiple approaches at the same time.

## 8. Conclusion

Although the development program did not go smoothly at first, patient communication between the Japanese and European engineers led to quick, strong teamwork that enabled the various challenges to be overcome. Technical support from the staff at PDE Automotive, who are talented speakers of English and German and immensely knowledgeable about the European market, was also crucial.

For the MMC engineers who worked on European COLT development, the project yielded more than just high-quality components; it also gave us new communication skills and a fresh appreciation of the need to look at new things without prejudice, listen carefully to what other people say, and express our own views clearly. We are convinced that the experience has equipped us to handle the next development project with even greater effectiveness and speed.



Norifumi MIKAMI



Kunio TAKAOKA



Shiro MORITA



Ken KATAOKA



Masahiro KANEDA



Masahiro INOUE



Akihiro HARADA