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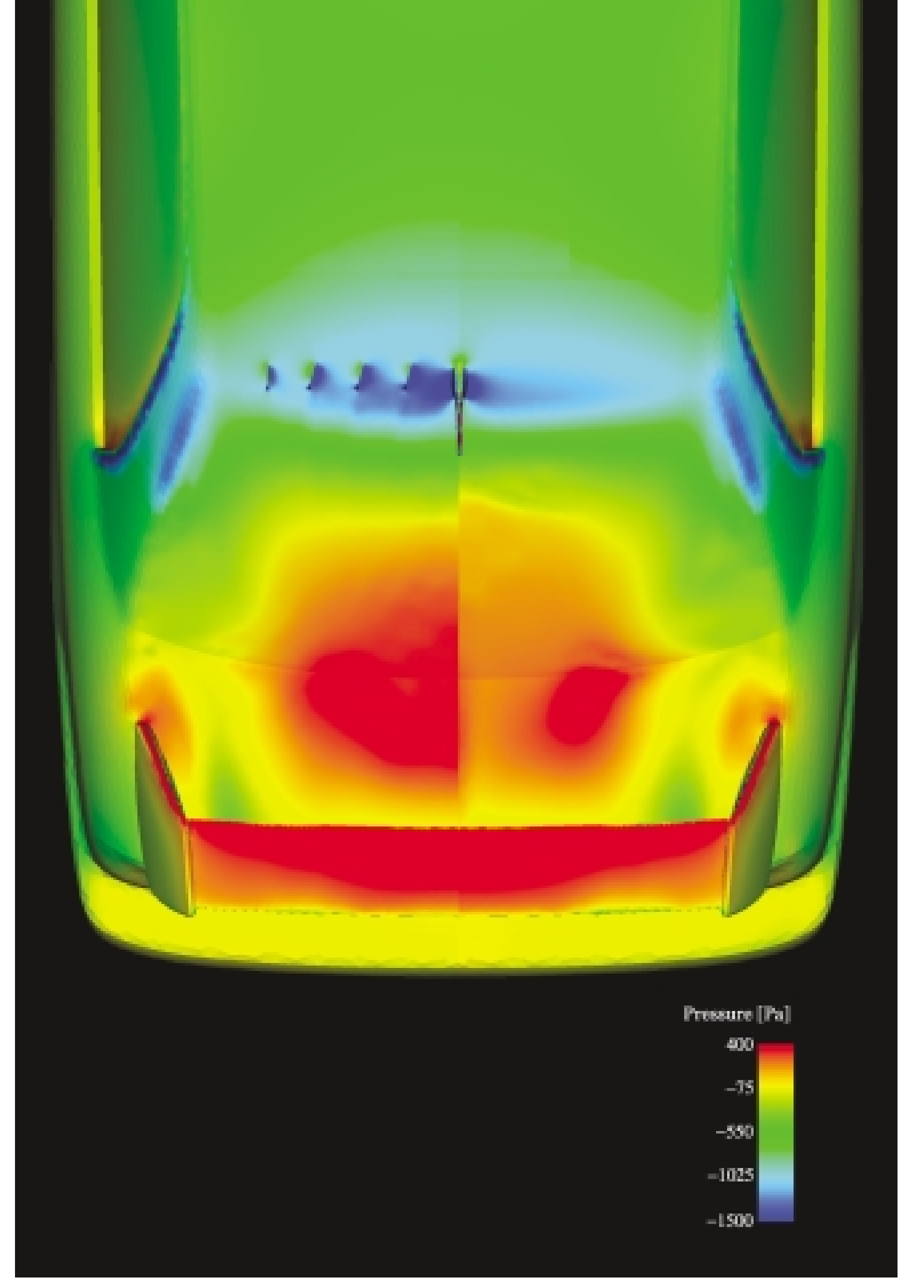

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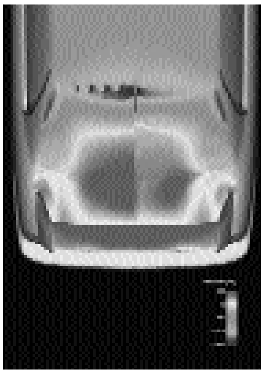

- **Cover Photograph**

The cover photo highlights the benefit of the vortex generators (VGs) mounted on the Mitsubishi LANCER EVOLUTION VIII MR, which was launched in February 2004. The left-hand side of the photo shows the pressure distribution with the VGs (which are located at the rear edge of the roof), and the right-hand side of the photo shows the pressure distribution without them. As shown, the vortexes generated by the VGs yield a pressure increase over the rear window and trunk. The result is a lower drag coefficient.

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Contents

Foreword

Further Refinement and Evolution of
Core Technologies through Global Interaction 4

Special Contribution

Methodology for Research Enabling 6

Technical Papers

Research on Aerodynamic Drag Reduction by Vortex Generators 11

Study of Engine Cooling Technologies for Knock Suppression
in Spark Ignition Engines 17

Gear Whine Analysis with Virtual Power Train 23

New Technologies

Development of “i” Concept Test Car for 2003 IAA
and 2003 Tokyo Motor Show 29

Development of Mitsubishi “i” Body 33

Development of Mitsubishi “i” Chassis 41

Development of Mitsubishi “i” Powertrain 45

Fuel Cell Vehicle Technology Trends and MMC Initiatives 51

Evaluation of CFD Tools Applied to Engine Coolant Flow Analysis 56

Development of Occupant Classification System for
Advanced Airbag Requirements 61

Development of Energy-Saving Air-Conditioning System for New COLT 65

Vehicles Evolving in the Ubiquitous Network Epoch
– Today and the Future of Telematics Services – 72

Photo on first page
The Mitsubishi FCV, a fuel-cell vehicle based on the Mitsubishi GRANDIS, was used in public-relations activities for the Osaka International Women’s Marathon, which took place on January 25, 2004.

Weight Reduction Technology for Improved Handling Performance of LANCER EVOLUTION 79
Development of New In-Vehicle Communications System 85
Development of Next Generation Diagnosis Functions 92

Technical Topics

Development of PAJERO EVOLUTION Rally Car for 2003 Dakar Rally 96
Shikoku EV Week 2003 100
Development of Tire-Pressure Monitoring System 103
Technological Trends in North American Markets 106
Euro NCAP and Improvement of Vehicle Safety Performance 110

New Products

MITSUBISHI MOTORS

New GRANDIS 114
New ENDEAVOR 116
eK·CLASSY 118

FUSO

CANTER "Ultra-Low-PM Model" 120
SUPER GREAT "Ultra-Low-PM Model" 122

On 6 January 2003, Mitsubishi Motors Corporation spun off its truck and bus operations to form a new company, Mitsubishi Fuso Truck and Bus Corporation. Beginning in 2004, the companies are publishing the *Mitsubishi Motors Technical Review* and *Mitsubishi Fuso Technical Review* independently of each other. Contact details for inquiries about the *Mitsubishi Fuso Technical Review* are shown below.

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Further Refinement and Evolution of Core Technologies through Global Interaction

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Last October, China succeeded in launching its first manned spacecraft "Shenzhou V", thus becoming the world's third major space power after Russia and the United States. The pace of human invention is accelerating, extending beyond the terrestrial world into space. We are living in a world quite different from that of a few years ago when technological development was led mainly by European countries, the United States, and Japan. Technological levels are becoming increasingly uniform around the world, as evidenced by China's rapid attainment of state-of-the-art technology, creating a common platform for sophisticated basic technologies on which countries compete fiercely for breakthroughs.

The automotive industry is no exception to this trend. Every automaker around the globe is striving to improve its technologies to ensure its survival. The key to remaining competitive is to further refine and develop the core technologies, and to act with a global vision.

Mitsubishi Motors' technological innovation is proceeding in line with its corporate vision of : "concept leadership and driving fun", "Japanese craftsmanship, engineering and design", and "environment friendly technology".

Today's major challenges for automobile engineers are to develop environmental technologies to reduce greenhouse gases and nitrogen oxides which are the worldwide demands, as well as passive and active safety technologies.

At the 2003 Tokyo Motor Show, Mitsubishi Motors presented an environment-friendly next-generation family of engines and the MITSUBISHI FCV, a fuel cell vehicle based on Mitsubishi's GRANDIS minivan body and DaimlerCrysler's latest fuel cell technology.

The next-generation family of engines includes three engine series having different displacement ranges while delivering the same performance and features such as high power, low fuel consumption, light weight, compactness, and low cost. All of them also sport an aluminum cylinder block and cutting-edge technologies such as variable valve systems. At the Motor Show, Mitsubishi also showcased its next-generation GDI engine, an improved fuel consumption version of the Mitsubishi original GDI engine, which offers a significantly extended stratified lean-burn zone.

In addition to these technological achievements in the driving components, Mitsubishi Motors exhibited weight reduction and other innovative technologies for the body, the essence of which was captured by the Mitsubishi "i", a concept car that uses an aluminum space-frame.

One of our solutions for the other major challenge, namely safety, is Mitsubishi's next-generation safety system achieved by using advanced electronics for both active and passive safety. This system was mounted in the COLT safety test car and demonstrated excellent results. The system is now under further development for commercialization.

As we learned through development of the new-generation engine series, the important point when developing innovative technologies is to consider the basis of that technology before advancing to the next step. This is especially true in today's world of technology where there are so many different fields of speciality. We should thus aim to improve the value of our products by first building a foundation of highly reliable core technologies and then adding to them Mitsubishi's original, specific technologies in order to satisfy customers' demands.

The second key to remaining competitive is to act on a global scale. This does not simply mean selling our products in international markets, but globally expanding our activities in all dimensions. The Mitsubishi FCV was developed in cooperation with our alliance partner, which is one example of corporate globalization in the field of development. Another example is the way in which Mitsubishi Motors is working closely with overseas suppliers in various areas, such as perfecting new technologies and products through technological cooperation at the early stages of development, and optimizing parts procurement on a global scale.

While we must embrace economic and technological globalization, we must also offer customers unique and distinctive products as people's lifestyles and tastes are becoming increasingly diverse. When responding to customers' needs, we must therefore do business on the global stage while keeping Mitsubishi's distinctive identity.

To create a distinctive corporate identity, a distinctive identity in technology is crucial, and this requires creating innovative and original technologies. To this end, we must consider technical development not only in the short-term but also from a long-term perspective. We will be able to create more exciting and enticing cars by combining such promising technologies as nanotechnology, information technology, and human engineering technology with automobile technology, and hence realize our potential through international, business, and academic interactions.

To do this, each employee must grasp the latest trends and technological information in their own field, and store that knowledge in a databank shared by all members. This new information must be processed into comprehensible knowledge, which must then be quickly used in the development of components and basic technologies. This will require courage, passion, and a strong sense of responsibility and mission. Some technologies require a long time and profound research before they work sufficiently; others should be implemented quickly to be really effective. Engineers must be sensitive enough to distinguish between these two types of technology and to achieve a good balance between the two. True technological innovation is possible by those engineers who understand and meet these requirements. Mitsubishi Motors also remains committed to technological innovation for minimizing impact on the environment and realizing safe, efficient, and clean driving.

This issue of MITSUBISHI MOTORS TECHNICAL REVIEW introduces many of Mitsubishi Motors' latest technologies and products. We will continue to use the MITSUBISHI MOTORS TECHNICAL REVIEW as an important means of informing our customers of Mitsubishi's current technological and production activities in the pursuit of providing all customers around the world with vehicles that bring pleasure to life.

Methodology for Research Enabling

Hiromitsu ANDO*

1. Introduction

"What man of you, having a hundred sheep, if he loses one of them, does not leave the ninety-nine in the wilderness, and go after the one which is lost until he finds it?" Japanese literary critic Tsuneari Fukuda quoted these words of Jesus from Gospel Chapter 15 of according to Luke and continued by saying that politics is for the ninety-nine sheep, and literature is for the one lost sheep. Fukuda went on to comment that "bad politics mobilizes pens to serve itself and forces the scholarly to ignore the lost sheep" and "second-class literature wanders around the ninety-nine sheep in search of the one".

When we consider the form that research should take in modern industrial society, Fukuda's comments are thought-provoking and relevant. The ninety-nine sheep signify success in business, and the one lost sheep relates to the veneration of and yearning for knowledge. When the words 'development' and 'research' are compared in this context, it can be seen that 'development' calls for the mind to seek only the ninety-nine sheep but 'research calls' for the mind to seek the ninety-nine sheep and the one sheep simultaneously.

If research is understood as mentioned above, describing it as 'fundamental' or 'applied' is not particularly meaningful. Ever since the concept of engineering was created, research in engineering has been supported by minds in pursuing profit. If engineering research is conducted in focusing only on the one lost sheep, in other words, with a focus on understanding fundamental phenomena, it ought to be called 'fundamental' research at all times regardless of its stages, from research-theme establishment to applied research and ultimate development.

Research management is a concept that was introduced a few years ago, and it has since been provoking vigorous arguments on how to position research in social foundation establishment models and business models. Consequences of these arguments in Japan include the 'Frontier 21' program of the Ministry of Economy, Trade and Industry (METI) and the 'Center of Excellence' program of the Ministry of Education, Culture, Sports, Science, and Technology (MECSST). Both of these programs have the same key research management concepts: 'designation of core fields', 'shifts toward short-term programs', and 'partnership between industry, government, and academia'. Similar initiatives have been launched by private businesses. In Europe and the United States, research management arguments are taking place on most basic issues such as how to bridge the gap, the so-called 'valley of death' between fundamental research and ultimate commercialization, whether to model research as a survival-type model or as an advancement-type model, and on whether to have research organizations independent as central research laboratories or to disperse them among business divisions.

The mission of an enterprise is to offer value to customers by way of its products, and this value is perceived by customers in terms of differences from the products that they are currently using. Consequently, enterprises are forced to deny the value of the products and the technologies used in them they already have on the market and continue to offer new products and create new technologies. If repetition of this value denial and new creation cycle is defined as 'innovation', most of today's innovations are underpinned by new technological know-how in areas such as materials, processing methods, and information technology (although product planning and application of existing technologies are important processes in the creation of new value).

The role of research in enterprise lies in the building up of new technologies/knowledge and in finding ways to transfer the enterprises' accumulated technologies/knowledge into the value of products. What should not be forgotten with regard to these roles of research is that technologies and knowledge accumulated in enterprises are self-growing and enabling this self-growth is also an important role of research.

Various arguments on the roles of research can be simplified if we use the key word "techknowledge", which the author coined for this particular discussion by combining 'technology' and 'knowledge'. All these arguments should share the following premises:

(1) The sum of accumulated techknowledge within an enterprise is an important element of the value of that enterprise.
(2) Only techknowledge can create new techknowledge.
(3) Techknowledge is a uniquely human property.

The most important role of research management lies in creating a vision for the techknowledge that forms the value base of an enterprise and in creating a system that supports and maintains the process of continuous self-growth of techknowledge. Only a system based on this vision can create the value the enterprise it deserves. Since techknowledge is the result of a unique human process, making a system for techknowledge growth and self-growth is not an easy task. In an ideal system in which techknowledge is actively created and automatically develops, the vision for new techknowledge must be presented in a comprehensive man-

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ner. An environment rich in techknowledge resources must be created in accordance with that vision, and individual researchers working in the techknowledge-rich environment must have a strong sense that they are helping to raise that environment to an even higher level.

To present this ideal system in a visible way to researchers, Mitsubishi Motors Corporation (MMC) has established subsidiary systems with the names 'House of Knowledge', 'Technology Database', 'Technology Trend Analysis Book', and 'Research Partnership'. This paper describes some of the fieldwork conducted by MMC to determine the orientation of these systems.

2. What is the current state of Japanese industries reflected by key performance indicators?

The hollowing-out of Japanese industry is widely recognized as the 'lost decade'. Many people seem to attach little importance to this phenomenon, seeing it as temporary and believing that the hollowed-out industries will eventually be restored. However, when the situation is examined via key performance indicators (KPIs), we find it extremely serious. They indicate that the rate of successful investment in research within Japan has been in continuous decline for the past decade. More important is that this trend is seen only in Japan. To deal with this situation, industry and government have been making significant investments in research (in terms of percentage of gross domestic product, these investments are greater than those made in the United States), but the situation shows no sign of improvement. Not one of the 38 epoch-making products recently listed in *Fortune* magazine was invented in Japan. Trade statistics including those for software and other intellectual property show considerable deficits. The number of patent applications per year made by universities in Japan is mere 206[(1)] compared with 5,591 in the United States and Europe.

There is a book entitled *Chuokenkyujo-jidai-no-shuen* (literal translation: The End of the Age of the Central Research Institutes), a translation published by Nikkei BP of a book originally entitled *Engines of Innovation*. That a negative-sounding title was chosen as a Japanese translation of the positive-sounding original title is indicative of the current environment of stagnation in Japan.

The 'valley of death' model has often been used to explain the current stagnation. Here, the 'valley of death' signifies the gap that must be crossed before fundamental technologies can be translated into actual products. According to one explanation of this model, the United States has an established industry-government-academia partnership system, has venture capital, and has major corporations that are keen to break into new fields. These mechanisms work successfully enough to cross the gap. Japan has none of these mechanisms and thus cannot cross the 'valley of death'. A number of political measures have been implemented in Japan to improve the situation, but they have led only to the marketing of products with limited applicability by small enterprises; Japan has yet to produce its own Intels or Microsofts. The 'valley of death' model assumes that, if help is given to cross the gap, unique products will be created. In other words, it assumes that Japan already has necessary fundamental technologies. The author feels this perception is wrong. What is lacking is a supply of new fundamental technologies; no innovative products can grow without new techknowledge.

3. In concepts, the key word is 'culture'.

Another explanation given for Japan's 'lost decade' is this: Japanese people were competent enough to achieve great economic growth by striving to catch up with the industrialized West, but they lacked the ability to subsequently pioneer new technological fields.

The author supposes that the key word underlying this explanation is 'culture'. During Japan's catch-up period, a profit-driven approach based on mass production and price competition was taken for the reason of by industrial needs. However, the end of that period saw a market where consumers possessed all the basic commodities necessary for daily life; apparently, their interest had already shifted to value-added products for a richer, more relaxing, more sophisticated way of life. In the author's view, industries in Japan, unlike those in the United States and Europe, failed to take this opportunity to mature the market culture into a richer one and hence were not able to create more intrinsically valuable products.

In today's Japan, there are a growing number of people who not only enjoy the physical benefits of an affluent society but also lead their life with a rich imagination. However, the ideas of these people seem to have little influence on Japan's industries. It is surely necessary to adopt product concepts that reflect today's popular culture no matter how juvenile they might appear.

The author believes that the concept of market culture must be given much higher importance, particularly in the automobile market. This is because today's culture with regard to automobiles is outdated compared with culture in other areas of daily life. The trend of residential interiors in homes is to conceal functional elements inside walls and create a simple appearance, but functional elements are most often exposed in automobile cabins. Drive controls and other control systems of automobiles are more complicated than home appliances, and their designs are far from standard. It is difficult to exchange or upgrade elements to suit different purposes because 'open architecture' is not yet an actual trend in the specifications of automobile electrical equipment.

In Japan, the METI a few years ago designated the key promotion fields of technological development as the manufacturing technologies that yield added intellectual value, technologies that address the needs of an aging society, technologies that address aesthetic needs, and complex systems technologies. In the author's view, this move was intended to invigorate Japan's industries with a focus on people and culture. However, the METI's new Frontier 21 program seems to have shifted the development promotion fields toward fundamental technologies.

4. In technologies, the key phrase is 'bottom-up vision'.

The Frontier 21 project designated the following four key promotion fields of technological development:

(1) Biotechnology and life science technology field
(2) Information technology and telecommunications technology field
(3) Nanotechnology and material technology field
(4) Environment field

Among these four fields, the environment field seems incongruous. While the first three are associated with distinct technical fields and there exist corresponding industries and scholastic fields, the environment field is conceived from the objective and does not correspond to independent technical fields.

In 2003, the MECSST selected several universities in Japan as 'centers of excellence for research' according to the key promotion fields of technological development it had designated. A large number of research themes were selected for the technical fields (1) to (3), but few were selected for the environment field.

The above disparity can be explained by this: While fields (1) to (3) are selected by 'bottom-up vision' (or inductive vision), field (4) is selected by 'top-down vision' (or deductive vision). When technologies and technological fields exist and research themes are selected based on concepts that are born from them, such a selection is made by 'bottom-up vision'. When the selection of research themes is made based on the concepts created from the objectives, such a selection is made by 'top-down vision'. The author has heard that many universities, selected as centers of excellence for the environment field, were given themes that either lacked concreteness in terms of achievement methods and content of research or, conversely, were too specifically defined.

Where selection of fundamental research themes is concerned, therefore, the important vision is 'bottom-up vision' rather than 'top-down vision'. In fact, the themes selected in the environment field for the 2004 financial year in the Frontier 21 project included carbon-nano-tubes and liquid-crystal-display technologies, which should all have been classified in the nanotechnology and material technology fields. This fact also highlights the validity of the bottom-up approach for research theme selection.

Techknowledge and mathematical theories about molecules, atoms, and other objects and phenomena lies at the base of the bottom-up approach. For example, with regard to research themes in the biotechnology and life science technology field and in the nanotechnology and material technology field, the techknowledge should be about molecules and atoms; for the information technology and telecommunications technology field, it should be about voice recognition, image recognition and encryption technologies in addition to molecules and atoms. Most of the innovative inventions announced recently are supported by new material technologies derived from techknowledge about molecules and atoms and by new data processing technologies supported by mathematical theories.

Research in the product development area requires market knowledge, technological knowledge, and business knowledge[2]. The approach market knowledge is playing a role in research theme is a top-down approach which requires identification of latent needs and a search to realize its technology.

Technological knowledge, on the other hand, should be given for its role a bottom-up thinking approach through which new base technologies are discovered and applications for them are sought. Needless to say, top-down and bottom-up approaches are both predicated upon techknowledge that has been accumulated and enriched within the organization. It is also needless to say that it is business knowledge that enables the final evaluation of the advantages and disadvantages of launching any new product.

5. The significance of research by enterprises is now being re-evaluated.

Today's business managers seem to have left behind conventional straightforward thinking about the role of research in technological innovation. Some seek ways to cut investment in research as a way to cut costs, thinking ahead to keep a cost model, while others look for research to play a pivotal role in overcoming the dilemma of competition. Positions vary widely, but every manager is striving to better understand the form that research should take.

Business models in which survival is pursued through improvement of existing products and manufacturing methods in order to reduce research costs are not successful because they preclude creation of the new value demanded by customers. The 'quickly making the second from the first' model is also difficult to use successfully because the lifecycles of products acceptable to customers are becoming shorter. Also business models that focus on research do not always work effectively. They may be seriously compromised by the scarcity of research themes that have been successfully commercialized and by the existence of continued research whose link to needs has already been lost or whose feasibility of being seeds of future research is virtually zero.

The author does not think it effective to analyze model-based arguments of the above mentioned types and become involved in them for better understanding of the expectable future form of research, because most of these arguments do not seem to have direct connection to the purpose.

To have a long-term vision of research, one must do a large amount of work to process a virtual matrix focusing on the future. Many people support the short-