The Toyota Motor approach from basic research to product realization

— Interview with Dr. Umeyama, General Manager, R&D Management Division —

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Toyota Motor Corporation is a world-class automotive manufacturer and unquestionably one of the most successful manufacturers in Japan. The company has been introducing new technology to society without being caught in the conventional concept for cars. Foreseeing the shape of an ideal society, their vision is reflected in the creation of the world's first hybrid automobile. The automobile is a compilation of diverse technologies, and there is hardly any technology that is not used in cars. The R&D Management Division is an integrator of technological development of all automobiles in the Toyota Group and includes the Toyota Central R&D Labs. We interviewed General Manager Umeyama of the R&D Management Division, and asked him about the flow from basic research to product realization at Toyota Motors, as well as his expectations for *Synthesiology*.

***Synthesiology* Editorial Board**
Interviewer; Motoyuki Akamatsu (Executive Editor)

Interview of Dr. Umeyama, General Manager, by Akamatsu on February 14, 2008 at Toyota Motor Corporation.

What does Toyota Motor wish to do?

(Akamatsu)
Seen from corporate side, national research centers and universities mostly conduct basic research. There is considerable lag time before the results of the research reach society and much research is buried and forgotten. Ever since the inception of the AIST, we have been concerned and carried out discussions on how to overcome this"valley of death" or "period of nightmare" in research so our results and development efforts can be put to use in industry. There are many types of research. Although certain kinds of research pursue one topic deeply, it is often necessary to combine several different technologies to create a viable product.

What processes are taken from basic research to product realization at Toyota Motor?

(Umeyama)
First, we face the basic issue of what we are trying to achieve in the automobile business. Not only should we make nice cars; we must consider "environment," "safety," and "comfort" to achieve a harmonious relationship between humans, urban centers, and the automobile. We try to set goals that people may question, "Is that really possible?" Like "a car that cleans the air as it runs," "a car that can go around the world on one full tank," "a car that will never crash," or "car that makes the passengers healthier as they ride." To achieve these goals, we look over all the technologies that are necessary and define the core elemental technology.

The R&D process includes advanced research, preceding development, and product development. Effort in R&D – Rotating the key man

(Akamatsu)
You mentioned three phases: advanced research, preceding development, and product development. How are they related? I don't think the results of advanced research can be used directly in preceding development.

(Umeyama)
There is an image that advanced research flows smoothly into preceding development, and a product is developed and is shipped out into the world. Actually it is quite difficult. Often, advanced, preceding, and product research are isolated

and on their own. The preceding developer thinks, “Advanced research is complicated, and there’s nothing I can do,” while a product developer may think, “Preceding development can think freely, but can’t come up with a product.” It is important how well these three phases rotate. I think in many cases, we see success by rotating the key man who will act as the core.

I used to do research on gear, so I speak from my experience. I had success by setting up a system where the advanced researchers worked jointly with preceding developers on noise and vibration problems in automobiles. Demand and practical methods were available in the workplace of preceding development. People of research worked hands-on, actually saw what were the problems, and ran experiments to see for themselves. Then they realized when research had to be stepped up here and there or expanded in range, or they saw some different form of application. They learned to pick things up.

When advanced research and preceding development talk to each other, they see the limit and potential of their theories, and I think that allows them to set the course of research.

(Akamatsu)
I see. From the opposite standpoint, solutions to problems that the preceding developers run into may be found by talking to the advanced researchers.

(Umeyama)
Yes. And if the researchers can realize that they can pick up new research topics there, they can appreciate the fact that development is a hotbed of exciting new topics.

(Akamatsu)
Do preceding development and product development have similar relationship?

(Umeyama)
The way things are done when going from preceding development to product development is quite different. Preceding development is a place where people investigate composition to meet the performance criteria set as goal. Since the goal cannot be achieved by thinking only about constraints, preceding development can work on the generation of a breakthrough idea to achieve the goal, and when they get something good, they hand it over to product development.

In product development, the concern becomes production technology conditions, weight, reliability, cost, and requirements as a product. Product development receives the results of preceding development, but in a way in which the receiving side handles the work done by preceding developers, who are emotionally attached to their own accomplishments, is very difficult. The results are not necessarily handed over to product development with all issues cleared, so if a preceding developer hands over a high-level demand saying, “You do the rest,” the product developer will have to suffer. If it is handed over suddenly without sufficiently communicating the relevant development information and without shared passion for development, one’s left to say, “I can’t do that!” So, I think it’s important to have a leader with passion to go from preceding development to product development, work together, encourage people, create the product, and then go back to his place. Therefore, I think it may be useful to rotate people between preceding development and product development on a three-year cycle.

Integrated research at Toyota Motor Corporation

(Akamatsu)
In automobile technology, I understand that product realization is achieved by the integration of several types of R&D. Has there been there any case where a single core technology directly evolved from basic or advanced research into a product?

(Umeyama)
For example, continuing my example of gears, if we wish to put a research result into practice and directly come up with a product, no, that doesn’t happen. A gear is attached to a shaft. If we don’t figure out the appropriate shaft and bearings, it can’t become a product. For automobile parts, I don’t think a single core technology can become a product.

(Akamatsu)
So, integration is necessary.

(Umeyama)
For research that requires integration, in the future I think it will become necessary to conduct physical and mental analyses of how a person riding in a car feels, and to clarify the relationship between the behavior of the driver and the control of automobile as hardware.

(Akamatsu)
I see. It is integration of technologies including the human user.

(Umeyama)
A car was made to be a tool used by humans, but why does it have this form? Is this form optimal for this tool? And, how do we add attractiveness beyond it being just a tool? Those fields have not yet been sufficiently researched. In such an integrated field, perhaps we can come up with different ideas by setting high goals based on “What are we aiming for in the first place?”

Barriers that must be overcome when integrating research results

(Akamatsu)
What do you think is the barrier to integrative research? Is it that people of advanced research intrinsically are unable to understand how people of preceding development see things?

(Umeyama)
When people of advanced research and preceding development talk, they often both think that the other is speaking a different language. For example, it's a battle between a researcher who bring up a research theme and think, "What, this guy doesn't understand this?" and developer who thinks, "He's making things complicated so I won't understand." This is a barrier, if you wish to call it so. I do think that there is a "language" barrier.

But, this is same old story. For example, the moment we see "R&D," I think Dr. Akamatsu and I have different meaning for the term. I don't think we can communicate unless we replace words with objectives and tasks such as "do what with for what and how," rather than relying on one word.

(Akamatsu)
Certainly. Making a roadmap with vision is one way of doing it. By sharing the goal, people will face the same direction and may start talking in common language. I think this may be the way to go.

(Umeyama)
Yes. It's hard to find exact match of words, so we must rephrase expressions several times and check meanings carefully "This means that, right?" and then finally common language is built between preceding and advanced teams. What are we targetting for? How are we doing it? How far are we taking it? If this sort of common understanding becomes eye contact communication like in sports, this is best. Nonverbal communication will then be possible and I think things will be progress much more rapidly.

Become a connoisseur of technology and incorporate technology

(Akamatsu)
The work of a research manager is important in overcoming barriers. Toyota Motor's chief engineer system is very famous. I think it can work for this purpose.

(Umeyama)
When making an automobile, the chief engineer coordinates the fabrication of the various parts and builds the car. For example, we made a good engine. We also have good drive transmission. The chief engineer thinks day and night how they can be combined to make something better. But in practice it's full of conflicts. The engine people make some demand, the transmission people say they can't, and the chassis people say that's impossible. Then, the chief engineer steps in and says, "Well, I understand your problems, but will you please think along this line so we can create a car?" He gets the developers to talk to each other beyond their expertise. He gives his own expertise and says, "If the pressure for this part is going to be 3 times normal, you can design this part assuming 3 times normal pressure." "I can't do that." "Why not?" "We'll have other problems." "Then let's get the engineer to re-design this with different conditions." He offers a type of intermediation.

The chief engineer tries to build a common language by setting up a common discussion. He listens to each pearson's claims, extracts common issues, and then throws back a solution. If it is an engine and a transmission, rather than fitting everything to the engine, he might suggests task of raising the performance of the engine through a system for transmitting torque. Then conflict subsides and collaborations begin.

To make a car today, we need a coordinator that can "fuse various fields together" who can understand each researcher's viewpoint systematically.

(Akamatsu)
In conducting such work, what do you think are the required abilities? Or what kind of human resources are necessary?

(Umeyama)
The person we need is the person who can climb half way up a mountain, but can stop and think that there may be something that can be used even if the final goal is set to be the mountain top. A person who thinks that he can get something better if he climbs a meter higher. A person who thinks how to utilize the results in hand at all times. It is ideal if the person works as a connoisseur to incorporate preceding development with product development. I really wish it would be possible for someone on the coordinating side could become a key person to bring out that sort of ability from researchers. I think a system where the leader says, "Hey, we can use this," and the researcher responds, "Yes, you may be right. Then let's try it." That kind of cooperation is necessary. In most cases, a researcher says, "See, here's something," but rarely does the "something" fulfill the

Dr. Mitsuhiro Umeyama

conditions for production, so he does not get listened to. If he is told, "Considering the total balance, that's not necessary," the researcher will be very discouraged.

I have stood between preceding and product development, and worked on incorporating various technologies to seek a specific solution. I have worked on development of hybrid cars with one main motor. If there were two main motors, one motor could be used to run the car and the other to start-up the engine, but that was not possible, so we added a separate starter system for engine start-up. There was a person who was developing stop-and-go engine (idling stop), and when I heard about that, I came to the conclusion that the deficiency in my system could be covered by introducing and combining this technology, and the combination was able to solve the problem.

Wide-ranging knowledge for connoisseurs; a story for the narrator

(Akamatsu)
That is a connoisseur. How does one learn to become a connoisseur, and what do you think is the education of a connoisseur?

(Umeyama)
I think that a person who knows a lot about diverse area should look at specific technology. In the research report meeting in our company, the researchers are very enthusiastic about talking about their research. People who listen build a story based on what they hear, and think, "This field may become an important focus field for Toyota Motor in the future." I think this is one kind of connoisseurship.

(Akamatsu)
Do you think a connoisseur should have research experience? Or do you think someone can become connoisseur without research experience?

(Umeyama)
Perhaps a connoisseur should have research experience, even in a slightly different field, to understand the behavior and personality of researchers, such as to understand "being totally engrossed in research." On the other hand, a researcher also must make an effort. For others to understand their research, they must learn to tell the "story" of what is the objective, what kind of approaches they have taken, and the results that were learned. I have researchers do a short presentation with a storyline that can be understood readily, and I think that helps others understand the research.

The receiving side must have a wide-range of knowledge to be a connoisseur, while the explaining side must have a story.

(Akamatsu)
I see. But I think there is a danger of being unable to communicate at all if the researcher fails to make a good story. Things may fall in place if there is story that attracts the connoisseur, but if the researcher writes story with the wrong characters, the storyline may get lost. What do you think about this?

(Umeyama)
I think it is important that the objective is clear and the direction of approach is told in simple steps. If the story gets lost, the explainer must work harder to promote the understanding of the listener, but I think the gap will narrow if both the explainer and the listener take time to talk with each other patiently and repeatedly.

On journal Synthesiology

(Akamatsu)
To change the subject, who would be the reader of the journal *Synthesiology* at Toyota? Who would find it most interesting?

(Umeyama)
First, it will be the connoisseurs. I think it will be useful for people who must have knowledge of a wide-range of fields. The journal presents both objectives and the underlying stories.

(Akamatsu)
Yes. We call the final goal the "dream," and how to conduct research to achieve that goal "scenario."

(Umeyama)
It will be very useful if the scenarios showing the development process of a research project are presented as in order and discussed systematically. For example, a certain discipline is working on such-and-such, and its objective is so-and-so. If this process is presented visually, I think I will able to read further into it.

(Akamatsu)
We ask authors to draw diagram of what they want to do, and what are need to accomplish their goals. When people write scenarios, I think they realize where they stand in the process, and the positioning of current results.

Interviewer: Motoyuki Akamatsu

Companies have technological reports that describe technologies that became the actual products, but it seems they are mostly elemental technology. I think an article on how a connoisseur combined technologies is suitable for *Synthesiology*.

(Umeyama)
Stories of achieving success including blockade and detours are encouraging. They serve as a record of a researchers' activities. Such articles are rare. What we emphasize are stories about someone decides to do something, he doesn't succeed with his initial approach, but gives it another try from the other side and succeeds. There is another way of looking at things. It will be great to have such articles.

(Akamatsu)
I think so too. I think it will be great to have article that shows the thinking process of how a person involved in R&D runs into a wall and how they go about solving the problem. For example, a researcher one day realizes that the person next door is working on a research topic that may solve his problem, decides to use it, and is finally successful.

(Umeyama)
I think it will be great to have a story about research done with a clear objective and with feet on the ground. I understand your intent, and I hope the work done at AIST can be widely communicated and will contribute to society.

(Akamatsu)
I think integration and synthesis of technology are mandatory to create automobiles, which are a combination of diverse technologies. Today, I was able to hear very valuable stories about effort as organization and necessary human resource to achieve the goal. Thank you very much for taking time to talk to us.

Profile of Dr. Mitsuhiro Umeyama

Completed masters program at Faculty of Engineering, The University of Tokyo in 1982. Joined Toyota Motor Corporation in 1982. Appointed to Transmission Design Division, worked on design of clutch operation system. In charge of preceding technology for a damper to reduce torsion vibration and development of driveline vibration analysis technology in 1985. Started research on adjustment of teeth surfaces for low noise gears in 1994. Obtained a degree for this research from the Tohoku University in 1997 (Doctor of Engineering). Placed in charge of development of the transmission unit for a hybrid car in 1997. Became general manager of the Technology Management Division in 2005, and manages R&D.