The Japanese Approach to Innovation: Research for D&M

Sigvald Harryson

It is conventional wisdom that Western companies are better at inventing and developing new technologies than at producing and commercializing them, while Japanese companies are particularly skillful at commercializing technology. In the preceding article, Thomas and Maira argue convincingly for a continuous exchange of knowledge between Design and Manufacturing as a way to improve the entire product development process – from conception to commercialization. They also illustrate some of the problems encountered by Western organizations that have tried to bridge the traditional distance between these two functions. In this article, based on extensive study and interviews in Japan1, we look at actual mechanisms used by two companies – Canon and Sony – to effectively bridge that distance.

First, some clarification of terms. For most Japanese office equipment and consumer electronics companies, there is no organization gap between Design and Manufacturing because both activities happen in the same place and are carried out by the same people. In this culture, the chain of innovation does not begin with R&D and end with Manufacturing; rather, it begins with Research followed by D&M (Design and Manufacturing). In most Japanese companies, Research consists of building and testing a prototype until it works. „Design" means the designing and development of a manufacturing process that can produce a perfect copy of the prototype. D&M means running and developing the trial manufacturing line until quality, speed, and costs are adequate. The question is, why is it that Japanese companies manage to commercialize new technologies that fail to reach the factory floor in most Western companies? How do they transfer their Research efforts to Manufacturing?

The answer is that they employ a number of effective mechanisms to tear down the walls that otherwise might separate Research, Design, and Manufacturing:

• On-the-job training and strategic rotation ensure that every member of the innovation process understands both the seeds of technology and the needs of manufacturing.

• Collocation of design and manufacturing farther strengthens the vital links of communication.

• Direct transfer of flexible researchers to the factory floor drives technological competence into products.

• The manufacturing floor is a respected place where the real value creation is realized.

• Networking with centers of excellence replaces excessive internal research efforts by researchers who may refuse to leave research.

Learning by Doing

These companies' successful synthesis of Research, Design, and Manufacturing rests on a fundamental principle: learning by doing. The lesson begins with the training and deployment of their researchers and engineers. At Canon, all researchers and engineers start their initial training program by spending three months working on a production line. (Although in recent years Canon has had to keep some trainees off the line due to declining sales.) Sony's training program includes an initial month of production work for both researchers and development engineers.

After working for some period – often three years – in the companies' research centers, most researchers are asked to join a development center. Most of the researchers who help create a product stay with the product through its development and manufacture. „The transfer of researchers is like breathing: both necessary and natural," said Dr. Makoto Kikuchi, former CTO of Sony. This promotes the transfer of knowledge from Research to Design and Manufacturing. Like most Japanese companies, Canon sees the principal role of Central Research as one of training and education. The real action takes place on the factory floor. Canon's quasi-institutional transfer of engineers from Development to Production reflects its technology-driven research orientation. If the technology of a product is new, none of the existing engineers in Production is likely to have prior experience with the technology. Thus, the transfer of the original researchers becomes imperative.

For example, in the development of ferroelectric liquid crystal (FLC) displays, 10 researchers initially pursued research on liquid crystal materials in the Canon Research Center. As the project advanced, most of these researchers were dispatched to the production site. From a three-man task force ten years ago, the FLC project has expanded to a 200-person operation, with 90 percent of all members located directly at the site of production. Most of these people were mobilized from within the company, mainly from the Research Center and some from supporting headquarters operations. The project depends significantly on the transfer of researchers and engineers for the design and manufacturing of the initial invention.

This same transfer of knowledge and experience is evident at Sony, whose Research Center offers more a period of education than a long-term opportunity. About 50 percent of the center's engineers are transferred to D&M after three years, and 80 percent after ten years. Therefore, Sony looks for flexibility in the researchers it hires.

Apart from foreign researchers, the company is not likely to employ Ph.D.s, who have been found to be relatively inflexible, preferring to stay within their field of specialization. During his time as Research Director, Kikuchi had difficulties finding Ph.D. candidates with both excellent scientific skills and the flexibility to change areas and levels of research.

He holds that those who do not have this flexibility should stay in the universities. „When we need a specific expertise for an important role, we do hire Ph.D.s in our Research Center. However, it is necessary that they be flexible enough to work in new, more product-oriented areas; otherwise their contributions to Sony will be of limited value.. .When we developed the charge-coupled device for our camcorders, 3 5 of the original 45 researchers followed the project to trial production in Atsugi. Only three of these came back to the Research Center," said Kikuchi.

Shuttling Developers

The following Sony project illustrates how closely the team follows the „product." The perpendicular magnetic recording project was initiated in the Magnetic Materials Research Group of the Research Center. A parallel project was set up in the Applied Magnetics Research Department of the Device Technology Research Laboratory, a corporate research facility, to work on a practical application of the new technology. Research went on in both groups, with frequent interaction between fundamental and applied research. When an engineering sample was prepared and presented to top management, Vice President (now President) Norio Ohga became very eager to incorporate the research results into a marketable product. Consequently, the Magnetic Materials Research Group moved to the Sendai Technology Center, a production plant, to develop a trial production line.

The new perpendicular magnetic recording group comprised researchers from the Sendai Technology Center, development engineers from the Applied Magnetics Research Department, and production engineers from Sony Precision Magnetics Corporation in Atsugi. They succeeded in developing some prototypes, but results were unsatisfactory due to precision problems. As this was a fundamental research problem, half of the group was sent back to the Molecular Materials Research Department of the Research Center to solve it. Not until a few years later could a satisfactory level of precision be achieved,[2] whereupon half the group of researchers again joined the Sendai group to continue the development of the production line. Their efforts finally resulted in successful production of the now well-known metal tape – an accomplishment for which the Molecular Materials Research Department received the President's Award jointly with the Sendai Technology Center.

Incubating Production

In the case of the Sony CD player, the complexities of the technology demanded a different path of flexibility – but the starting point was the same: begin with manufacturing in mind. Sony and Philips had agreed upon 1982 as the launch date. Due to Sony's use of compound semiconductors in the junctional lasers, which constitute the core of a CD player, the process technology was very complicated. All research on compound semiconductors and junctional lasers was done within the Research Center, which had both the competence and the instruments to develop prototypes.

Dr. Kikuchi realized that it would be impossible to develop such a complicated production line in Atsugi before the launch date. Therefore, he decided to develop a small production line in the Research Center, despite strong protests from the subordinate researchers. Hence, the first two years of production of junctional lasers were accomplished in the Research Center and the launch date was met. A full-scale production line was prepared in parallel in Atsugi, where production continued after the first two years.

Interactive Development

In some cases, interactive development complements or replaces more formal transfers of engineers. In Sony's mass memory project, no researchers were transferred. Instead there were repeated meetings between researchers and development and production engineers. Dr. Kikuchi says the key success factor in this approach is a strong project leader. „Otherwise, such a project will never succeed." According to Sony's former Chairman, Akio Morita, the main criteria for becoming a project leader at Sony are to have prior experience with turning an invention into a commercial product by being engaged in the research and design and manufacturing of the product; to be open minded and able to communicate freely; to be able to set clear goals; and to have a good sense of the market.

Japanese researchers do not necessarily like abandoning research for more production-oriented activities, but they realize that technological competence is useful to the company only if it reaches and is understood in manufacturing. Open communication is important on both sides and is enhanced by the fact that the researcher either has come from Research to Production or knows that he or she will end up in Production at some point. Cooperation thus comes naturally to both functions.

Thinking Ahead and Looking Outside

In addition to requiring that people follow the project, companies such as Canon and Sony begin thinking about manufacturing issues when new technology projects are in their infancy. No research activity is approved unless the researchers have a commercial application in mind. This approach of „research for design and manufacturing“ is further strengthened by the fact that research in Japan consists of little more than building prototypes and modifying them until they work. Once they do work, it's only logical for the researchers, with all their experience, to take the project into production.

Of course, this policy of pushing researchers out of the labs means that the labs no longer can serve as havens for the development of deep, long-term expertise. Japanese companies can accept this because they are adept at looking outside themselves for original research. They have developed highly sophisticated external networks for the effective acquisition of technological competencies and scientific results. In the case of FLC, for example, Canon sourced a Western technology that no Western manufacturer dared to invest in because of lack of manufacturing expertise. When Canon acquired the technology, it immediately focused on the manufacturing process, transferring most of its FLC researchers to the manufacturing site.

Canon uses its external networks not only to acquire technology, but to buy – or rent – any further scientific competence that may be necessary. The original FLC inventors, Professor Sven T. Lagerwall of Sweden and Professor Noel A. dark of the United States, still pay frequent visits to Canon. For further advanced research of FLC materials, Canon gets help from several other domestic and foreign universities.

Relationships with Suppliers

The close relationships between Japanese companies and their suppliers help speed up the design and manufacturing process. For example, FLC displays had never been mass produced before, and additional manufacturing know-how, together with new equipment, was required. Close interaction with suppliers began as soon as the pilot production line was created in 1988. According to Senior Researcher Akiko Tanaka, „We studied the technology together, which was advantageous for all of us. The key suppliers could acquire more knowledge of our FLC technology and its development, and we could build know-how about the production technology.“

Canon maintained intimate contacts with several suppliers of equivalent equipment, with the purpose of acquiring knowledge of the latest production technologies and increasing competitive pressure on the suppliers. The suppliers were involved in each of the project's core technologies: FLC materials, molecular alignment, cell fabrication, drivers and controllers, and interfaces. Tanaka said that ten suppliers (or „co-developers“) were closely involved in the development activities of all the aforementioned core technologies. Equipment was not purchased until it had been confirmed for mil-scale manufacturing.

As illustrated here, Canon and Sony have a highly production-oriented approach that begins with an idea for a marketable item and determines the path that the idea and its developers will take. „Research“ is a way station on the road to the closely combined entity of Design and Manufacturing. The companies' cultures naturally blend Research, Design, and Manufacturing together in ways that are certainly worth considering.

[1] *'The article is based on the author's doctoral thesis, for which he interviewed more than 100 people, including Akio Morita, former head of Sony: Sigvald Harryson,* Japanese R&D Management: A Holistic Network Approach, *Ph.D. thesis submitted at the University of St. Gallon, Switzerland, Research Institute of International Management (to be published in 1995).*

[2] *This technology called for combinations of scientific methods and tools such as reflection high energy electron diffraction analysis and a multisource sputtering system.*

The author would like to thank the many interviewees who generously shared with him their valuable time and insights. He is also grateful for encouraging support from his colleagues Nils Bohlin, Jean-Philippe Deschamps, and Kamal Saad.

Sigvald Harryson is based in Arthur D. Little's Stockholm office, where he helps clients improve their R&D operations. He is also a lecturer on R&D management at Lund University in Sweden.