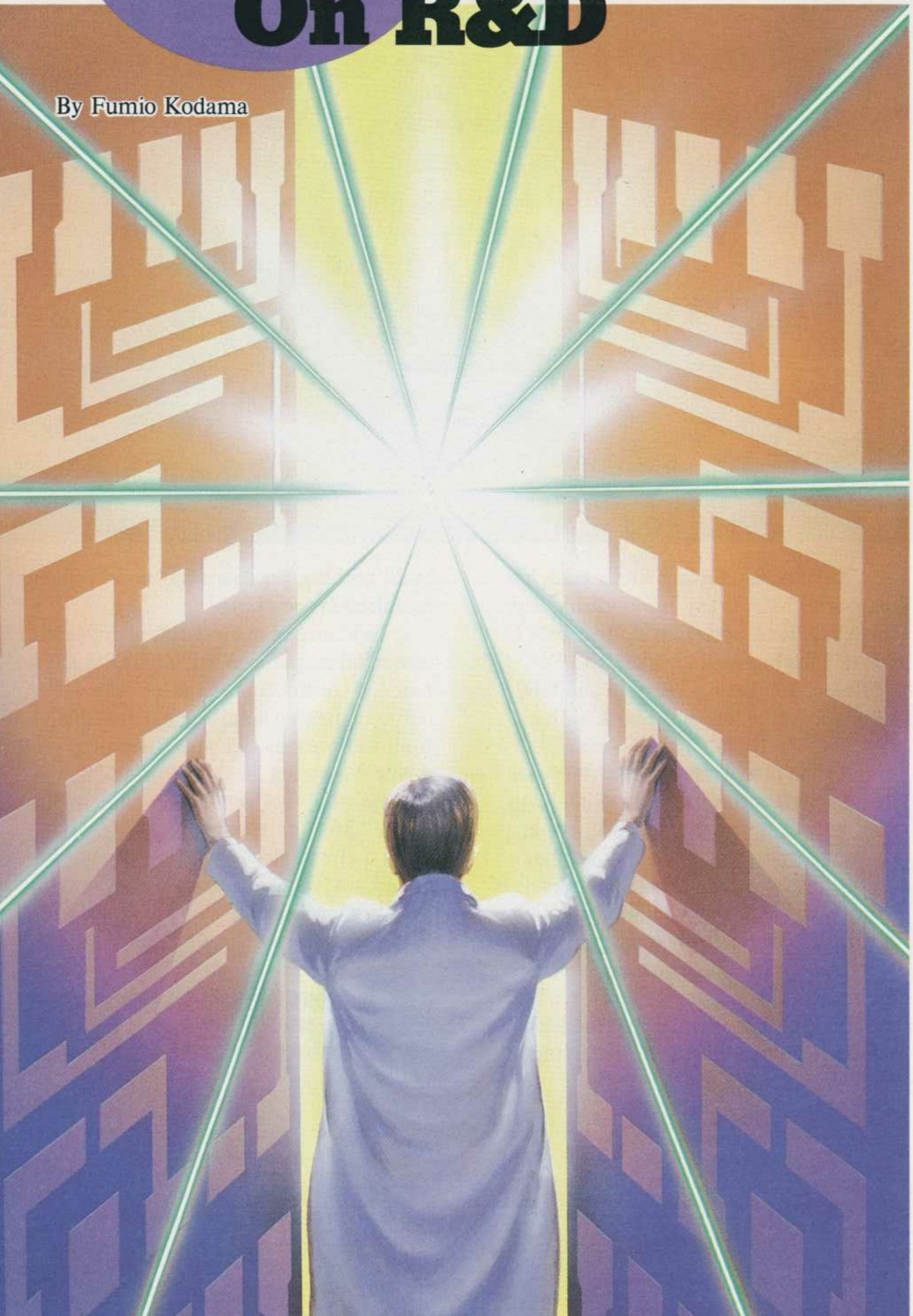
# Charting a Policy On R&D

By Fumio Kodama



There have long been calls, both within Japan and abroad, for Japan as the world's newest economic superpower to start contributing more to the international community in a number of fields, including science and technology. Whatever Japan does will have to be within the context of its own historical circumstances, however, and it is impossible to debate a country's international contribution without also considering that heritage.

Most people agree that it is especially critical that Japan, because of its extremely rapid growth over the last 40 years, place a premium on policy continuity. Postwar Japan has seen rapid evolution in its political goals, and has responded by implementing the most appropriate policies for each stage of development. In the process, Japan has provided the world with a series of revolutionary breakthroughs, both in technology and in policy terms.

Consequently, it is important to start by looking back at and analyzing R&D policy in Japan and then to offer ideas on whether a continuation of the same policies is adequate to solve the issues we now face or if it has become necessary to devise entirely new policies. In other words, do we want continuity or discontinuity?

## Staying on top

Japanese postwar technological policy has been characterized first and foremost by the government's refraining from direct intervention and instead offering information and recommendations to form the guiding principles for industrial development. This government input helped Japanese industry delineate the directions of technological change and stimulate business efforts to stay on top of the technological revolution. It may thus be said that Japanese technological policy was formed and implemented on the principle of indicative planning.

The second major feature characterizing Japanese R&D policy has been the major emphasis on building a strong engineering infrastructure. The laying of this infrastructure was carried out at every level of the production process, starting with the finished goods themselves, and then moved backward to the building of manufacturing facilities and the development of materials. In terms of technological content, this strategy promoted developments first in assembly technology, then in component technology, and finally in materials technology. In more abstract terms, this was a sort of "needs-pull" approach that started with the downstream products and then worked back upstream to develop whatever was necessary for their production.

A few examples might make it easier to understand the fundamental ideology behind Japanese R&D policy. Two of the best are the move to numerical control (NC) of manufacturing and research on very large-scale integration (VLSI).

## Unfair image

Japanese have been scorned as great technology utilizers but lousy innovators. This is not, however, an entirely fair appraisal. Japan has, for example, contributed major innovations in the area of technology fusion, which includes such technologies as mechatronics and opto-electronics.

Although now a part of the English language, the term mechatronics was coined in Japan in 1975 to describe the marriage of mechanical and electronics engineering. The computerization of machine tools through numerical control, a classic example of mechatronics, first took off that same year. How did this mechatronics revolution in the machine tool industry come about?

It all started when Fujitsu, a leading manufacturer of communications equipment, came out with a miniaturized, highly reliable controller called the stepping motor. This stepping motor worked by the principle of open-loop control, as opposed to feedback control. As a result, deterioration anywhere in the system rendered the controller ineffective (such deterioration being backlash caused by wear and tear generated by the friction screw). The solution was a ball-screw developed by NSK, a leading manufacturer of bearings. Additionally, the stepping motor, although finely adjustable, originally had weak torque, but this problem was overcome by coating the machine tool's sliding bed with Teflon.

The mechatronics revolution was thus made possible by a fusion of technologies from the electronics, machinery and materials fields. What were the policies that brought about this technological fusion?

In the beginning, policies promoting the development of electronics technology were implemented independently from policies aimed at promoting machinery technology. In 1956, the Law on Temporary Measures for the Development of the Machinery Industry was passed for the purpose of promoting machinery technology, and in the following year the Law on Temporary Measures on the Development of the Electronics Industry was passed to do the same for electronics technology. The main thrust of both of these laws was to provide long-term, low-interest financing for industrial technology development efforts from the Japan Development Bank and other semigovernmental institutions.

In 1971 the two laws were combined to make the Law on Temporary Measures for the Development of Specified Machinery and Electronics Industries in explicit recognition of the importance of the mechatronics revolution. That this was the purpose is clear from the minister of trade and industry's reference to "the consolidation of machinery and electronics into one" when he explained the need for the legal revision in the Diet.

## Popular approach

Research consortiums came to be a popular tool in the Japanese government's R&D policy. Within these consortiums, numerous companies that were in competition with each other pooled both capital and research personnel to establish research laboratories and conduct joint R&D. The government also provided considerable assistance to these joint research centers through project funding and various tax breaks.

A prime example is the consortium for doing research on VLSI formed by Japan's five major chip manufacturers between 1976 and 1979. To make sure there was no conflict of interest, the consortium did not do R&D on chip production technology but concentrated on the experimental development of manufacturing equipment and ways to improve the process for crystallizing the silicon used in computer chips. A large part of the research was subcontracted out to companies that were not members of the consortium, including equipment manufacturers and silicon suppliers.

The consortium's R&D efforts ultimately led to the development of the optical stepper by camera manufacturers and provided scientific data pertinent to the silicon crystallization process for silicon suppliers. In effect, joint research efforts by chip manufacturers paved the way for the consolidation of the engineering infrastructure needed for the production of chips in Japan. This is an excellent example of the needs-pull approach—joint research by product manufacturers in the downstream sector that yields benefits directly applicable to such upstream sectors as production equipment and materials.

What will happen in Japan if the concept of continuity is adhered to? In line with the needs-pull approach, since the strengthening of the engineering infrastructure is already complete, the next step would be to strengthen the scientific infrastructure in the upstream sector. In tandem with this, the indicative-planning principle would lead the government to try to supply information relating to goals and hence to direct industry's allocation of basic research resources into the most promising fields. It would be critical that the government define the most appropriate policies and goals, just as it did in the past with its revolutionary system of research consortiums.

But can the continuity approach be effective? Is this the best way for Japan to solve its problems? Let us draw some conclusions by looking at the Human Frontier Science Program proposed by the

Japanese government at the 1987 Economic Summit in Venice.

## At the frontiers

As the name states, this program is an attempt to expand the frontiers of science. Underlying the policy decision to embark on this type of program was the realization that traditional scientific disciplines are inadequate to address tomorrow's issues and that we need to create new disciplines in the interests of benefiting the entire world.

In other words, this program is distinctive in that it not only straddles a number of scientific disciplines but goes on to explore entirely new areas. And it will thus be impossible to derive useful information from these research programs unless the government provides the necessary R&D funding and direction. Without that, there will never be a consensus on what needs to be done. In other words, indicative planning and other such forms of indirect government assistance might not be enough any more.

The needs-pull approach is essentially characterized by its gradualism of implementation and its budgetary incrementalism. Research involved in creating whole new fields of science needs more vigorous momentum, however, because of the threshold-level principle requiring that research funding and other resources have critical mass before any success can be achieved. The bottom line is that Japan must discard its traditional continuity approach if it is to contribute to a better world and meet the world's basic scientific research expectations.

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