YOKOGAWA CORPORATE R&D STRATEGIES FOR THE YEAR 2015

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INTRODUCTION

As technology advances at an accelerated speed, many products have come to achieve functionality and performance at levels higher than market requirements and in short turnaround times. Now is the age of increasingly commoditized and modularized products. In this age, competition over "things" that have a material form, changes to competition over total solutions that combine engineering and service. As things that may greatly affect survival in the competition, there are some key factors that will decide the performance of solutions and will not be commoditized. We envision specific, ideal solutions that are considered essential to the market in the year 2015, and have isolated these key factors from such solutions to research and develop them.

THREE R&D PARADIGMS

Corporate research and development is an activity intended to create such achievements as can bring major breakthroughs in the future market. This activity is so important as to affect the future development of companies. Therefore, it is necessary for us to begin now, to arrange those research themes which will prove to have been the correct choices in 10 to 20 years' time. This is proof of the emphasis that we are placing on R&D strategies.

At Yokogawa, the direction and validity of research and development are evaluated on three axes: 1) corporate philosophy and action guidelines, 2) business development rules and initiatives, and 3) market and technological trends (see Figure 1). The first axis, "corporate philosophy and action guidelines," lays down the basic guidelines to be observed when each Yokogawa Group member takes action. The second axis, "business development rules and initiatives," defines the basic business development policy that specifies the directions toward which R&D activity should be geared. The third axis, "market and technological trends," shows the future trends of markets at which R&D activity is aimed, as well as the future trends of technologies that will play key roles there. From these three axes, Yokogawa maps out its medium to long-term R&D strategies that may bring innovations in the future. These three paradigms are explained in "Yokogawa Corporate R&D Strategy for Continuous Growth" in Yokogawa Technical Report, No.39, 2005, pp.1–3, and will not be discussed here. Figure 1 summarizes the three paradigms.

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R&D STRATEGIES

Basic R&D Strategies

The mission of the Corporate Research and Development Headquarters as the corporate R&D department of Yokogawa, is to contribute to the Yokogawa Group and society through R&D activities. The headquarters is expected to develop strategic technologies that will enable us to create new business areas and new product categories. The following are the three basic strategies designed to meet these expectations:

(1) The headquarters will watch market and technological paradigm shifts to identify the "ideal markets" of the future and will serve as a navigator for future technologies. The headquarters will reflect on the fact that its conventional research activity has been based too heavily on the seeds of technology. Rather, it will focus on creating new expectations in order to accomplish its dreams. To this effect, the headquarters is endeavoring to discover market needs that must be met in future, through positive communication and/or joint research with advanced users and people in academia both in Japan and abroad.

(2) The headquarters will create new technologies that may bring innovations in future and will serve as a "supplier" of strategy elements that will help secure the competitive edge of the existing divisions. It is another important mission of the research

Figure 1 Three R&D Strategy Paradigms

department that the department itself develops strategy elements that will materialize expectations being created in new markets and provide the elements to the department or division in charge of the business in question — rather than just relating its dreams and possibilities. The headquarters is especially concentrating on the fields of device and network technologies where technology progresses day by day and the utilization of new technologies and the speed of developments determine relative merits.

(3) The headquarters will refine the core technologies it has accumulated and owned in the measurement, control and information service fields, in order to create strategic technologies that can be developed into forming new markets. In this age, many competitors are very likely making similar R&D efforts. The key to winning the competition, therefore, depends on whether we can achieve this development speedily. We will work with industry-government-academia collaboration in mind, without falling into the trap of "do-it-yourselfism." In the research of new key technologies and development of subsystems, however, we will attach importance to "do-it-yourselfism" and secure a future competitive edge.

Research and Development Approaches

Yokogawa has adopted two approaches as its method for promoting research and development:

(1) In-depth developmental approach
This is an approach traditionally taken by Yokogawa and is primarily employed for hardware-focused R&D efforts. It is the process of making a thorough, in-depth pursuit of themes to be accomplished; producing dedicated devices that will realize our competitive edge; and building them into killer applications. Yokogawa has been developing in-house those dedicated devices which serve targeted purposes, rather than simply assembling commercially available general-purpose devices. It has thus brought breakthroughs in the market and has been securing its competitive edge.

(2) Analysis-based solution approach
This approach is primarily employed for software-focused R&D efforts. It is the process of analyzing the ideal target markets of the future; identifying common market needs; and creating technology components that meet those needs. Yokogawa has applied this approach to the research and development of in-the-field ubiquitous computing. It is promoting activities to search out prospective common components and forge them into strategic technology components. In this approach, it is also important to build interfaces with these common components not only as in-house standards but also as de facto industry standards.

Strategic Technologies to Concentrate on

Yokogawa operates on three core technologies — measurement, control, and information service. From the viewpoint of applying strategic technologies that combine these three technical fields toward the year 2015, it has defined three technological categories: 1) micro-measurement and manipulation technologies, 2) technologies for managing field-ubiquitous computing, and 3) photonic measurement and control technologies, in order to concentrate on its research activity.

Micro-Measurement and Manipulation Technologies

Function realization by means of miniaturization and microstructuring is available as one means out of conventional technologies for achieving major breakthroughs. Yokogawa has been concentrating on the in-house development of characteristic semiconductor devices based on its own technologies, in order to achieve the strenuous levels of performance and functionality required of measurement and control equipment. It is our key devices based on micromachining technology that have been responding to basic needs for sensors, including high accuracy, high speed, space saving, and energy saving. The most typical of these are the sensors developed by means of micro-electro-mechanical systems (MEMS) machining. Yokogawa began researching resonant pressure sensors based on the silicon MEMS process in the 1980s. Now they have gained global recognition as high-performance sensors. The MEMS technology is applicable not only to silicon but also compound semiconductors, glass and resins. In addition to evolving silicon sensors, Yokogawa is promoting the application of this technology to micro-reactors and biotechnical diagnosis cartridges.

(1) Semiconductor Devices Development
Achieving breakthroughs and a competitive edge in the marketplace by developing characteristic semiconductor devices is the basic strategy of Yokogawa. Yokogawa will continue to actively develop these devices. As devices have become more sophisticated and faster than ever, mechanical aspects of development, such as packaging and signal coupling, have become increasingly important recently. Yokogawa is therefore concentrating on the research and development of packaging technology, in addition to design technology. Yokogawa has achieved a delivery record of well over 1.7 million MEMS process-based high-performance sensors. It still focuses on improving their performance and conducts the research and development of new MEMS technology-based sensors.

(2) Micro-reactor Technology
Micro-reactors are a focus of attention, mainly in the fields of pharmacy and chemistry, as an innovative method for producing small lots of high value-added functional chemical materials. By bringing chemical reactions in microscopic flow channels using the MEMS technology, it will become possible to realize reaction fields that have never been feasible before. This method will enable us to take a theoretical approach to chemical reactions and is expected to bring innovations in our development methodology. Yokogawa aims to be the leader of micro-reactor research and development by leveraging its accumulated MEMS technology.

(3) Gene Analysis Systems
The 21st century is said to be the age when the life-information industry will blossom, where mechanisms of life-phenomena will be incorporated in industrial technologies to aim for a sustainable world. One approach in this area is realizing "personalized medicine" tailored to each individual's health requirements and carrying base by means of gene analysis. By applying both the accumulated high-sensitivity fluorescence detection technology and MEMS technology, Yokogawa will develop DNA chips capable of isolating DNA from a specimen, amplifying it, and preprocessing it in microscopic flow channels, as well as gene-reading systems. Yokogawa thus aims to provide mother tools for personalized medicine.

Technologies for Managing Field-Ubiquitous Computing

Yokogawa has a great deal of experience and a long-established track record in field computing that supports the world of manufacturing. It is therefore convinced that it is the leader in this area. In the realm of field computing, computers perform measurement, monitoring, control and

managerial tasks in parallel with the control of oil refinery plants or automobile assembly lines. The wave of ubiquitous computing is also rolling into this realm. The characteristic features of a ubiquitous information society that will also be called for in the future world of manufacturing are — "accessible from anywhere at anytime," "without being aware of the actual accessing of information," "extraordinarily real," "from the user's standpoint," and "adaptable changes."

Yokogawa has surveyed the market of field computing in the broad sense, including not only the management of manufacturing sites but also building management and the management of wide-ranging social systems. Then, it has selected three R&D themes — 1) field networking, 2) real-time use of process models, and 3) application multiplexing, as core technologies that will be necessary in the future, and is working intensively on these themes.

(1) Field Networking

The Ethernet/IP networks have dominated "officedom" and have even swept through the domain of manufacturing execution systems (MES) which are higher-order systems in the manufacturing domain. From this trend, we can readily assume that these networks will also serve as key technologies in information exchange in the field. Yokogawa was among the earliest to begin engaging in the research and development of IPv6 that will make the use of Ethernet much easier than ever. Based on the achievements and experiences thus gained, it aims to realize IP-critical networks in the field and network security. Yokogawa also aims to realize wireless sensor networks as a means for complementing IP networks.

(2) Real-Time Use of Process Models

As advanced countries reach full growth and developing countries grow dramatically, it has become extremely difficult to assume that there will be as many plant-operating engineers as are needed. Consequently, we can expect that the enhancement of plant operation support functions to a higher degree than ever will be necessary. Yokogawa will make real-time use of its accumulated plant modeling and simulation technologies, in order to realize a system that will enable us to:1)estimate in real time those data which cannot be measured, 2)detect faults early on, and 3)perform proactive plant operation based on predictions. Furthermore, Yokogawa is studying how to realize a system in which two or more similar plants can be operated using common expertise by absorbing the differences among them using plant models.

(3) Application Multiplexing

Primary tasks, such as monitoring and control, which are expected to be undertaken in the field, have been upgraded by linking them vertically with management systems or horizontally with front-end processes and/or back-end processes. In addition, there is an increasing demand today that security and safety be ensured and extensive applications such as energy saving and system maintenance be implemented on the current system in an multiplexed manner. Yokogawa has been promoting research and development on the assumption that, like personal computers, equipment arranged in the field also requires the same system as those of online general-purpose computing platforms. By enhancing the functionality of this equipment, Yokogawa aims to realize a system in which controllers, sensors and a variety of other equipment in the field will work together systematically to concurrently undertake various tasks.

Photonic Measurement and Control Technologies

Increasing the speed and capacity of information transfer is only feasible by means of optical communication. We are convinced that optical technology will be extremely critical to future society. Yokogawa began the research and development of compound semiconductors in the early 1980s, with a view to applying them to measurement. It procured semiconductor process equipment in-house, developed ultrahigh-speed devices, and assembled them into high-performance measuring instruments and semiconductor testers, thereby contributing to realizing Yokogawa's competitive edge. Based on the technology thus accumulated, Yokogawa has developed its compound semiconductor technology into use for the optical communications infrastructure itself, with the aim of performing business operations that will contribute to social infrastructures in the telecommunications field. In the process, it has been working on the research and development of a family of next-generation 40 Gbps modules. Furthermore, Yokogawa has succeeded in developing optical switching devices capable of switching signals at ultrafast speeds. Yokogawa has made efforts to build a system around these switching devices, thereby leading to the proposal and demonstration of a new optical packet network. Thus it has accomplished what has been commonly considered to be only feasible ten years from now. We will continue to make various improvements to this network. Concurrently, we will promote the research, development and practical use of the network, with the aim of launching it onto the market as early as possible and promoting it to become a de facto standard.

(1) Key Components in the Measurement Field

To be able to realize various communications systems, we will need to have concurrent technologies for measuring and evaluating these systems. Yokogawa is promoting research and development in order to contribute to the development of both optical communications components and next-generation communications equipment and high-performance measuring instruments.

(2) A Family of Next-generation Communications Modules

Yokogawa has been promoting the development of compound semiconductors in order to apply them to the optical communications infrastructure itself, thus succeeding in developing a family of 40 Gbps next-generation communications modules. Until now, Yokogawa has been supporting the social infrastructure with industrial instruments. From now on, it will promote business operations toward the future information and communications age so that it can contribute to the social infrastructure also in the telecommunications field. In this market, key issues are not just limited to the characteristic aspect of products, such as high speed. The high long-term reliability level of devices is another crucial point.

(3) Optical Packet Networks

Yokogawa will aim to build a system based on the successfully developed optical switching devices that can be switched at ultrafast speeds, in order to put the optical packet network to practical use. In the course of this effort, Yokogawa has configured a system which takes advantage of the devices' ability to switch signals a million times faster than conventional technologies. Thus the system directly switches optical signals in optical packet communication without converting them into electric signals, and identifies labels packet by packet. This network is comprised of these optical switches and the Optical Media Manager that serves as an interface with conventional networks. A demo system is already in operation at a customer site. Yokogawa will repeatedly make improvements to the system and release it onto the market at the earliest possible date so that it can be used on a practical basis.

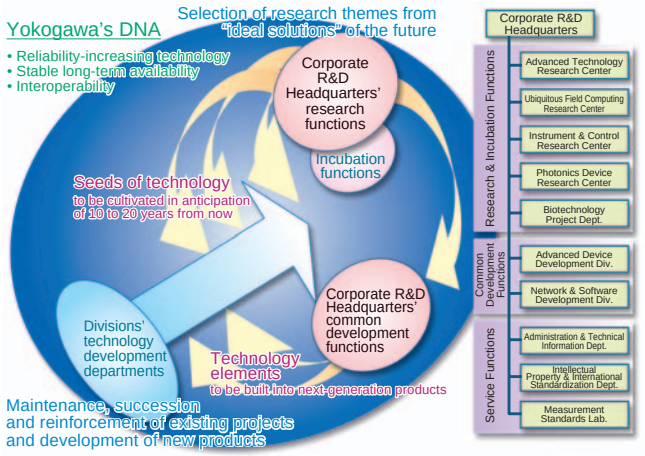

Figure 2 Research and Development System

SYSTEM OF RESEARCH AND DEVELOPMENT

The Corporate Research and Development Headquarters is composed of a research department, common development departments, and a service department. Figure 2 shows the research and development system of the Corporate Research and Development Headquarters. The research department selects research themes from "ideal solutions" of the future, conducts research in anticipation of 10 to 20 years from now, and develops strategic technology elements. In addition, the department creates technologies that may serve as a basis for entering new business fields. For each technical field, four small-scale labs and one incubation project have been set up in the department. Upgrading technology elements which are the research results of these organizational units and providing support for commercializing the results are the responsibility of the development departments. Concurrently, the development departments own strategic advanced technologies common to the company as a whole to support each division in developing next-generation products. Currently, the Advanced Device Development Division consisting of the two development departments and the Network & Software Development Department are in place at the headquarters. The Measurement Standards Lab is in place at the service department and is making an effort to ensure and upgrade measurement traceability which is the starting point of our business.

INTELLECTUAL PROPERTY AND STANDARDIZATION STRATEGIES

Yokogawa's intellectual property strategy holds true based on the harmony between protection of the continuity and profitability of customers' businesses (assets) and active acquisition of advanced technologies that may bring breakthroughs in the market. Believing that the former is especially critical to customers, Yokogawa concentrates on realizing interoperability in multi-vendor products. It has therefore been active in participating in activities to formulate and popularize global standards. Yokogawa is especially proactive in participating in the standardization of fieldbuses and IPv6 protocols that will play important roles in the future market. It thus actively takes charge of formulating specifications and certifying interoperability.

On the other hand, Yokogawa is endeavoring to acquire strategic, comprehensive intellectual properties in unexploited fields of technology. Also in technical fields related to standards, it is working to acquire intellectual property rights used to secure a competitive edge in the methods of implementing those technologies. Yokogawa focuses particularly on acquiring intellectual property rights that will help realize high reliability, high precision, high performance, high stability and low costs.

In addition, believing that defensive measures and resolute battles are necessary to protect customers from becoming involved in disputes over intellectual property rights, we are hammering out such measures.

Table 1 In-House Reforms toward a Global Company

	The Old Yokogawa	The New Yokogawa
Target markets	Focused on Japan	Global
Business services	Manufacture of material things	Production of tangible and intangible products
Management priority	Sales-focused	Profit-focused
Added value	Created from equipment and labor	Produced from creativity and intellectual property
Management organization	Pyramid	Flat
Employee composition	Centered around regular employees	Based on diversified employment status
Employee rating	Seniority	Achievement and added value

APPROACHES FROM MANAGEMENT

Yokogawa's management shares the understanding that innovative research results will only blossom commercially after a long period of incubation. Looking back on Yokogawa's history, we also realize that great successes were only achieved after nearly 20 years of tenacious incubation. Consequently, management believes it important to 1) realize healthy and profitable operation to make it possible to invest continuously in necessary research and development efforts, 2) enhance the enthusiasm of R&D engineers, and 3) provide an environment in which they can demonstrate their creativity.

On the other hand, the environment of the markets Yokogawa aims for has changed drastically. We are on a fierce battleground where only those companies which are eligible as leaders in global, international markets can survive. Table 1 summarizes the reforms Yokogawa has carried out in order to play an active role as a global company at the international level.

CONCLUSION

The age has gone at last when expectations for corporate labs were on a short-range and bottom-line basis. Now we are entering the age when R&D results are expected to have great significance for the future of companies. However, people should reflect on the traditional addictive research attitude that "technology before anything else." We believe that researchers should be business-motivated and explicitly aware of their desire as to what sort of breakthrough they want to achieve in what application. For this reason, a pressing need is to cultivate those enthusiastic researchers who do not confine themselves to a narrow technical domain but have wide-ranging viewpoints, curiosity and a spirit of taking on new challenges. ◆