R&D Strategy of Fujitsu Laboratories —Toward a Human-Centric Networked Society—

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Since Fujitsu brought the message "Everything on the Internet" to the world more than ten years ago, Fujitsu Laboratories has made progress in information technology, leading to innovations in services and business models. Fujitsu Laboratories holds to the vision of a "human-centric networked society". Enormous amounts of data and knowledge will be acquired by sensors, processed by Cloud computing, transformed into new forms of value, and fed back to the real world to bring about big social and business changes. "What Mankind Can Dream, Technology Can Achieve" is our mission. We are going to innovate ourselves as 21st century laboratories, contribute to the creation of the human-centric networked society, and offer a fruitful and hopeful future to the whole world.

1. Introduction

In the more than ten years since Fujitsu first brought the message "Everything on the Internet" to the world, barriers to information, communications, broadcasting, cellular devices, and home electronics have been clearly lowered worldwide. The many advances made by Fujitsu Laboratories in information technology (IT) have given rise to innovation in services and business models in a variety of industries.[1)–4)]

These first ten years of the 21st century have seen progressive commoditization of networks and information technology. The coming decade is also expected to bring even greater human-centric social changes. Fujitsu Laboratories is facing the challenges brought by those changes by actively constructing a vision of "research and development (R&D) activities for achieving a human-centric networked society". We believe that major social changes, increased business opportunities, and other such substantial changes can be brought about by sensing the various kinds of information and acquiring knowledge from the environment that surrounds individuals and by providing it to the Cloud via a network, converting the immense amount of collected knowledge into new value, and feeding it back to the individual and to the business environment that surrounds individuals.

What social infrastructure is required to achieve that? What technology is required to implement it? We believe it is important to place people at the center while taking a strategic and scenario-based approach to R&D by focusing on changing events and then developing technologies and products.

In this paper, we introduce the R&D strategy that Fujitsu Laboratories is applying to fulfill the vision of "What Mankind Can Dream, Technology Can Achieve".

2. 21st century laboratory

The 20th-century enterprise laboratories produced research results linking science and engineering to make new business possible. They occupied an era in which progress

in semiconductor process technology and communication technology was linked directly to progress in IT business. However, from here on, that will not be the end of the process. Researchers themselves have a clear image of the end product of their research results, and they must have an awareness of producing new business while considering corporate social responsibility, or how new business models and their own technology can serve society. For example, device researchers must be concerned with generating demand-pull innovation in the form of a technology value chain that concerns what kinds of equipment incorporate the devices they develop, what kinds of solutions and services that equipment provides, and what value to the customer is created by them. That is to say, a transformation into a 21st-century-style laboratory that aims for customer-initiated R&D and human-centric R&D is needed.

Fujitsu Laboratories currently has laboratories in three locations outside Japan, namely in the USA, China, and Europe. The major research results produced by the excellent minds at those foreign facilities have provided R&D support for the expansion of Fujitsu's global business. The transformation to a 21st century laboratory is proceeding globally under this scheme through the R&D activities listed below, which are described in more detail in the following subsections.

1) Roadmap-based R&D activities related to business while looking forward ten years into the future
2) Open innovation activities utilizing cooperation between industry and academia
3) Business incubation activities aimed at opening new markets
4) Strategic public relations activities for mass media, investors, and analysts
5) Cultivation of personnel

2.1. Roadmap-based R&D activities

For strategic evolution that is soundly linked to business, R&D must proceed under the guidance of a roadmap that serves as the key to technology management and with information sharing that extends from the supervisor level to upper management. To achieve that, we must create an R&D roadmap for all of the elemental technology that Fujitsu Laboratories deals with. That roadmap must be premised on market and social trends, technical trends, trends in other companies, standardization trends, and other outside trends. It must also consider the technical strengths and technology strategies of Fujitsu Laboratories and reflect its technology development plan for the next ten years and the product planning of the business unit. Finally, all of that information should be stored in a database. The technology roadmap is updated every half year and reflected in the construction of the following year's research plan, etc., thus serving as a communication tool for discussion on drafting a general strategy aiming at reforming the direction of the roadmap-based activities. Information extracted from the database is presented in **Figure 1**.

The roadmap lays out the challenges to be taken up from the present into the future and a strategy for dealing with them. However, an effective approach to discovering technology that is not currently being treated but will be necessary later is to look back from a future viewpoint to the present by drafting of a vision of ten years ahead and considering the technology needed to achieve that vision and what we should be doing now in relation to that technology (**Figure 2**).

For that purpose, we set up a "Ten-year Vision" Working Group in 2005 to begin studies on future society and the technology required to achieve it. Work on formulating a vision that aims for development into future business has been proceeding since 2007. This vision, shown in **Figure 3**, holds up the promise of "creating value by connecting all things and using that value to offer people 'feeling', 'discovery', and 'trust and development' to achieve a human-

centric networked society". The ten-year vision, like the roadmap, requires activities for adapting to new environmental changes and continuous overall optimization. The activities of this ten-year vision are expected to serve as a platform for future strategic research activities.

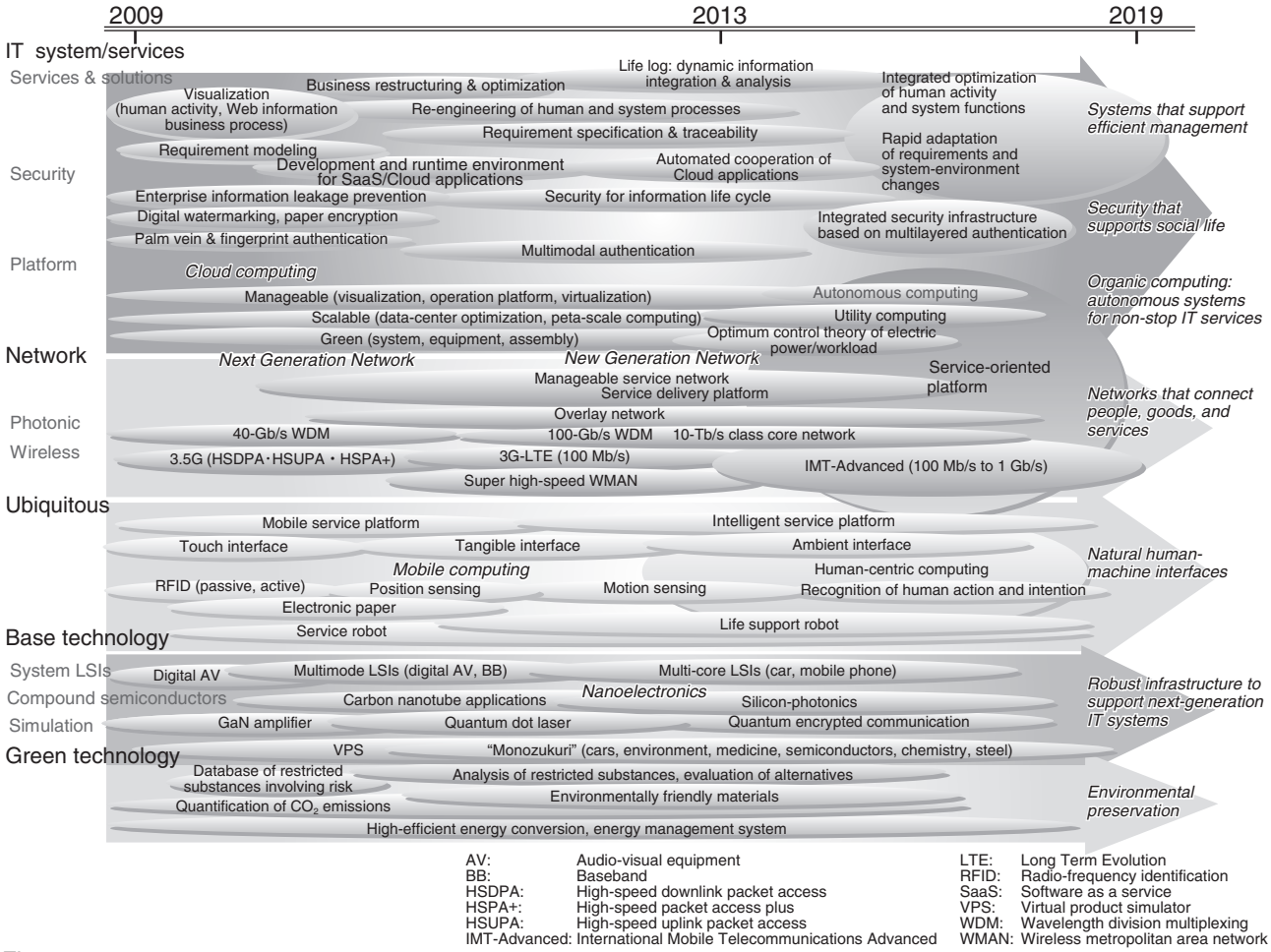

Figure 1
R&D roadmap.

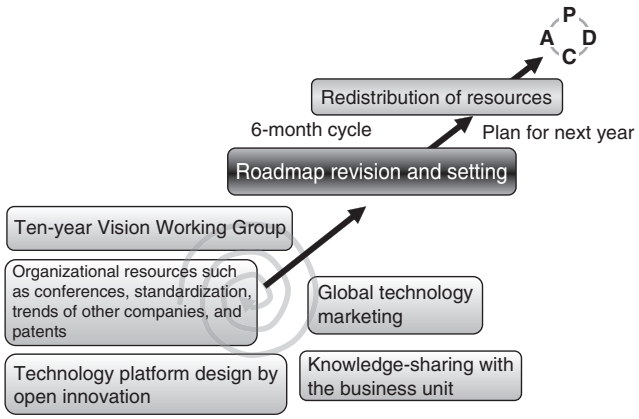

Figure 2
Roadmap-based R&D activities.

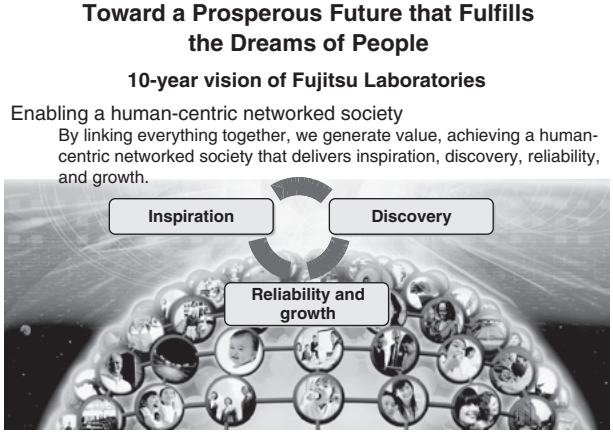

Figure 3
10-year vision of Fujitsu Laboratories.

2.2. Open innovation activities

As the intimacy between Fujitsu Laboratories and the business sector has increased, the priority assigned to research topics related to business development has increased. Required research, including basic research, has previously all been done under the 20th-century model of the enterprise laboratory that conducted its own work according to its own principles. To follow market changes and devise new technologies that create value for customers requires open innovation activities that involve stronger cooperation with other companies that possess special areas of expertise and with universities, which have a broad base of fundamental knowledge and a global viewpoint. To cope with the era of open innovation, Fujitsu Laboratories is actively using outside technology. Activities based on that strategy include strengthening cooperation between industry and academia, making use of national projects, and strengthening joint research with other companies.

For industry-academia cooperation, the main activities in the past were research projects commissioned to foreign universities, but the environment of industry-academia cooperation in Japan was greatly improved by the change that made national universities into corporations in April 2004. Previously, university faculty members mostly retained the rights to their inventions as individuals, but after incorporation, the inventions became university property. That shift changed the form of cooperation from a relationship between an enterprise and an individual faculty member to one between two organizations.

Organizations such as intellectual property departments are being set up within universities. A series of laws, including the Law Promoting Technology Transfer from Universities to Industry (TLO Law, 1998), the Industrial Revitalization Law (Japan's version of the Bayh-Dole Act, 1999), and the Industrial Technology Reinforcement Law (2000), has also established a legal basis for circulating university research results back to society for effective use. According to the budget of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), financial support for industry-academia cooperation is also being strengthened.

Fujitsu Laboratories has also greatly changed its policy on industry-academia cooperation to shift the focus toward joint research with universities in Japan. An examination of expenditure for funding the commissioning of university research shows that industry-academia cooperation previously focused more on foreign rather than domestic universities. Furthermore, in the relationship with domestic universities, most of the funds were allocated as scholarship contributions aimed at employing students. In 2005, research funding for domestic universities was twice that for 2000, surpassing the amount paid to foreign universities for the first time. A breakdown of payments to domestic universities reveals that in 2000, 61% went to scholarships, 29% to commissioned research, and 10% to joint research. In 2007, however, the proportions had shifted to 31% for scholarships, 22% for commissioned research, and 47% for joint research, making joint research the mainstay of industry-academia cooperation. To promote smooth progress in joint research with universities, we are engaging in organizational cooperation with several major domestic universities.

A typical example of industry-academia cooperation is the work done on nanophotoelectronic device technology. Since 2002, we have engaged in joint research on nanooptical device technology with the University of Tokyo Nanoelectronics Collaborative Research Center (NCRC), which is headed by Professor Yasuhiko Arakawa. Although the proposal for the quantum dot, a key element of that research, was presented by Professor Arakawa in 1982, our joint research brought the technology closer to serving as a source of business. A special

feature of that joint research was the setting of clear topics based on an image of the commercial end-product and the construction of a system for the complementary division of work among the excellent researchers assigned by the University of Tokyo and Fujitsu Laboratories. The joint research also involves the exchange of personnel by universities and enterprises and personnel development such as student training. The results of that joint research are linked to new business, and in 2006, QD Laser, Inc. was founded as a joint venture investment of Mitsui Company and Fujitsu. This is a good example of contributing to society by making use of the knowledge of universities and establishing a link from basic research to business-generating research through joint research. Two other technologies with promising futures are artificial antibody technology and technology for measuring the properties of proteins, which are topics of joint research with the Technical University of Munich.

With regard to using outside resources, we are also actively participating in national projects as a strategic activity. The research topics selected for national projects are mostly important for the future, and, in particular, we are participating in projects that promise to raise research efficiency beyond what a single company can do independently through collaboration with strong universities and enterprises.

Joint research with other companies and outside research organizations is also an important means of accelerating research through open innovation. We began joint research on knowledge computing with Xerox PARC (Palo Alto Research Center) in 2004. In networking, we are proceeding with joint research with the Fraunhofer Heinrich Hertz Institute in Germany and performing collaborative work with Cisco and Alcatel in the business sector as well.

Now that we have transitioned from the catch-up era to front-runner era, enterprises like Fujitsu must create new value. In meeting that requirement, the knowledge possessed by universities, which pursue fundamentals and principles, is indispensible, and Fujitsu Laboratories must make the utmost use of that knowledge through industry-academia cooperation to produce innovation. Rather than setting individual topics, it is important to set fusion-type topics that encompass a broad and deep range of topics. What is first needed is a topic-setting framework that pools the knowledge of people from different industries and different fields for a given purpose. We will continue to create new value and achieve open innovation related to the development of Fujitsu business.

2.3. Business incubation activities

In recent years, market expectations for new technology have been rising, but business risk will remain high, and the timely development of technology into products demanded by the market will remain difficult until the markets rise. For example, no department was assigned responsibility for developing business based on Fujitsu Laboratories' world-leading authentication technology based on the detection of veins in the palm of a person's hand. The marketing department and the Laboratories worked together to explain the technology directly to customers, who presented over 400 requests, and they negotiated with financial organizations for its application to automated teller machines, which carry a high social risk, and this led to deployment of this technology. International standardization is currently in progress, and the assigned business development unit is developing the technology into a global business. This is the optimum model for achieving the 21st century laboratory in which we go from our own research results to the creation of value for customers (**Figure 4**).

To produce a succession of examples like this, we believe that a stepwise approach to going from technology to business results is needed for research topics that are not understood

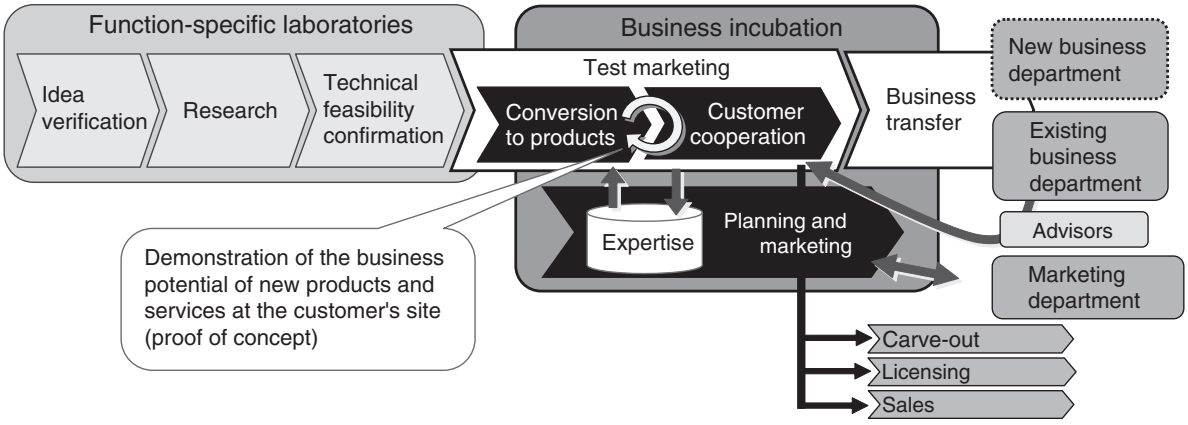

Figure 4
Business incubation process.

clearly by the business sector. Five time-limited commercialization projects were set up for rapid new-product development based on laboratory technology, the opening up of new markets, and the conversion of the technology into business, but the issues involved in conversion into business differed among the individual projects, so the textbook methods did not yield good results. We therefore emphasized practical and empirical knowledge and set strategies for converting technology into business individually, according to the situation of each project. Through our activities so far, we have been able to define the process of converting new technology into business in terms of the minimum that must be studied and implemented. The process of going from technology to business involves the four phases of topic studies, business development, business feasibility confirmation, and technology transfer. What is to be implemented in each phase is summarized in the form of guidelines for converting new technology into business. Fujitsu Laboratories is conducting new R&D activities and business incubation activities that are coordinated with the technology roadmap by means of a phased portfolio.

2.4. Strategic public relations activities

To increase the name recognition of the Fujitsu Group and expand business, we are strategically raising public awareness of our results through presentations at scientific conferences, press releases, Web publishing, participation at exhibitions, and so on.

In 2007, we made about 400 conference presentations and paper contributions in Japan and about 200 more in other countries. We also issued about 100 press releases concerning research results during the year to publicize the high level of our technology. Among such activities, there has been a high demand for explanations of the overall situation of the laboratory's endeavors, and we have been holding sessions for explaining our R&D strategies to the mass media, investors, and analysts in April every year since 2006. In those meetings, we announce the latest results for the year as well as important points and strategic topics. In that way, we strategically publicize the future direction of the Fujitsu Group and platform technology for achieving "What Mankind Can Dream, Technology Can Achieve". Each year about 100 reporters are invited to the announcement of the latest results. In April 2009, about 80 articles subsequently appeared around the world.

We have also received various awards from outside organizations. In the last ten years or so, we have been awarded three Medals with Purple

Ribbon for the development of the high electron mobility transistor in 1998, an advanced elastic surface acoustic wave filter in 2003, and a color plasma display panel in 2004. We also received the Okochi Award, the Prime Minister's Award in 2008, and the MEXT Minister's Award in 2009.

Exhibition centers are an important way to accommodate visitors to the laboratories. In 2003, the exhibition center for the Kawasaki area was completely remodeled to improve the displays. There are now about 40 permanent exhibits for the Kawasaki area, 20 for the Atsugi area, and 20 for the Akaishi area, and they draw about 2000 visitors a year. About 40% of those visits relate to business discussions. In addition to an overall reconsideration several times each year, we also work through the Fujitsu Forum, the technology forums of laboratories in other countries, press releases, participation in exhibitions, Fujitsu exhibition centers, and Fujitsu's netCommunity.[5)]

In addition, Fujitsu Laboratories is actively working to expand points of contact with customers. In 2002, we set up an Information Data Center (IDC) Laboratory within Fujitsu Laboratories and followed up by establishing the Broadband & Ubiquitous Laboratory and the Security System Laboratory in 2003. Working together with the marketing and sales departments, we invited customers to the laboratories for direct exchanges of opinions and comments on upcoming research topics. We also greatly increased the opportunities for introducing laboratory technology to customers by bringing the researchers themselves face-to-face with the customers. These activities also serve to heighten the sensitivity of the researchers' social awareness.

2.5. Cultivation of personnel

Personnel in the R&D sector are a vital managerial resource, and securing, training, and raising their abilities is one of the most important goals for laboratory management. Fujitsu Laboratories is currently introducing a business model approach to R&D, aiming at the 21st century laboratory, and we are implementing continuous personnel development from the time employees join until the time they leave (**Figure 5**). Recently, the employment of

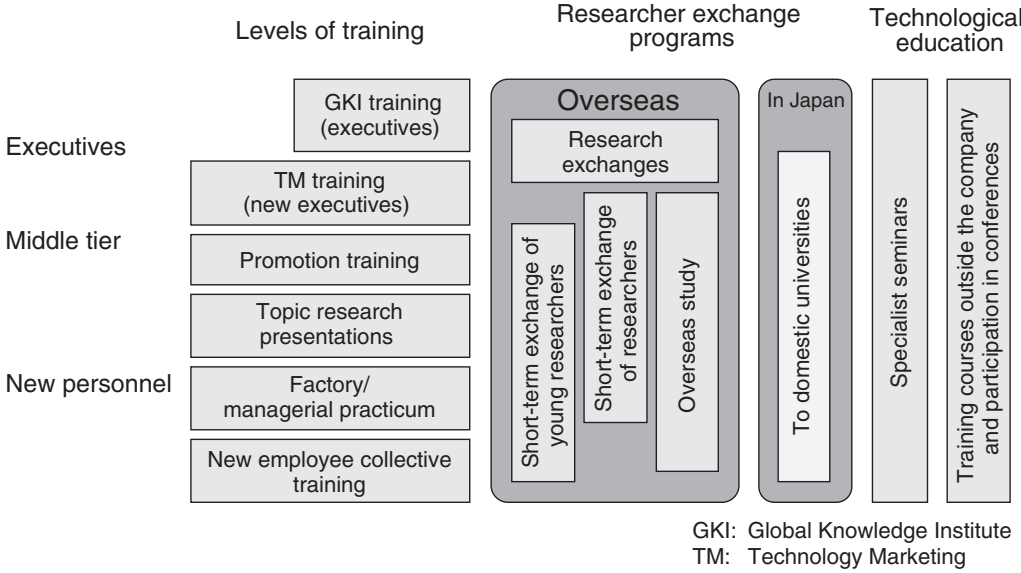

Figure 5
Development of personnel.

researchers from other countries has also been increasing, and steady progress in diversification is also being made.

From the Laboratories' viewpoint, the main desirable employee qualities are:

1) Mastery of one area and capability in several others
2) Capability to identify issues as well as solve problems
3) Attitude that is always ten years ahead in theoretical thought
4) Ability to think and act globally
5) Good communication skills
6) Ability to achieve self-improvement (persistent and goal-oriented).

The cultivation of personnel naturally involves raising skill levels in each field of specialty, but it also extends beyond that to fostering concern and interest in other fields and developing a multi-faceted field of view.

In each stage of training, the Technology Marketing studies conducted for new executives, in particular, allow R&D managers to acquire the market, technology, and management viewpoints they need and to learn how to relate their own research topics to business results (business models).

We should continuously strengthen global personnel development from now into the future, and one system that could greatly contribute to that goal is the Technologist Training System. It comprises the following three elements.

1) Short-term exchange of young researchers

This aims to give young researchers an international viewpoint in individual fields of research. Although the term is short, about two weeks, it provides a good opportunity for young researchers to expand their experience in other countries.

2) Short-term exchange of researchers

For the more experienced researchers, programs of exchange with researchers of other countries aim to deepen insight into specific research topics.

3) Overseas study

Researchers who have been in the Laboratories for three years or more can be assigned to one year of foreign study under world-class leaders in the field. Each year, about seven people are sent, and so far 120 researchers have participated in the program. The foreign study leaves the researcher possessing advanced technological abilities and specific results that can be linked to business development and energized to serve as an important human resource.

In addition, the Visiting Research Scholarship Program, which invites world-class researchers from other countries, and a program for interns from other countries both began with the invitation of a few people. In the last few years, however, there has been a constant stream of invited researchers that has invigorated globalization from within.

In the future, we will continue to move towards the global development of Fujitsu Laboratories by gathering researchers from the diverse cultural backgrounds of Japan, the USA, Europe, and China and encouraging cooperation among them and by heightening the effect of synergy by focusing on the further development of our people.

3. Conclusion

The environment surrounding Fujitsu and Fujitsu Laboratories is changing greatly. For Fujitsu to continue to grow and develop in the changing managerial environment, incessant reforming of our business structure is essential. Fujitsu Laboratories must also continue to change in response to Fujitsu's changing business structure. At the same time, our mission is continuous production of research results to seed new business. The President of Fujitsu has quoted the words of Dr. Robert H. Goddard, "Yesterday's dream is today's hope and tomorrow's reality". To put the meaning of these words into concrete form, we must first continue to have dreams. Achieving the concept of "What

Mankind Can Dream, Technology Can Achieve" is the goal of Fujitsu Laboratories. Fujitsu will continue to grow by placing importance on technology and continuing to create new value. Fujitsu Laboratories will transform into a 21st century laboratory in the true sense. As a member of the Fujitsu Group, we will continue contributing to building a human-centric networked society in which people can live comfortably and at ease and continue to offer the people of the world a future of abundance and dreams.

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