# Current Status and Prospects of Automation Technology

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**ABSTRACT**

Fuji Electric has expanded its automation business in various fields, such as for power and industrial applications, and has compiled a record of many successes. Based on our technical strategy for the Japanese market and on global market and technology trends, Fuji Electric is advancing technical development focused on energy, the environment and safety with the goal of realizing a sustainable society that is a safe and secure. With smarter functions, improved safety and greening seen as the critical factors for success, Fuji Electric has subdivided its automation business activities into energy, industry and socio-automation sectors, and is advancing efforts to realize safety engineering, platform development that includes embedded systems, and "3R" (reduce, reuse, recycle) engineering.

## 1. Introduction

Fuji Electric has been engaged in creating the latest measurement control technology and information technology in the power, water treatment and transit sectors of the social infrastructure field, the iron/steel and petrochemical sectors of the basic materials industry, the electric and electronic sectors of electromotive power applications, the assembly and processing industries, and as applications to commercial buildings and stores., Fuji Electric has developed an automation business for realizing power savings, automation, higher efficiency and higher reliability, with a record of many pioneering accomplishments. Aiming to realize next-generation automation that will contribute to resolving such social issues as global warming, low birthrate and aging society, the realization of safety and security, and economic issues such as globalization and how to improve competitiveness, Fuji Electric is presently advancing technical development with a focus on the energy, environment and safety fields.

## 2. Current Status and Trends of Automation Technology

### 2.1 Technology strategy in Japan

The strategic technology roadmap formulated and published by the Japanese Ministry of Economy, Trade and Industry, focuses on critical technology, and shows installation scenarios, technical maps, and a technology roadmap. The fields of energy and measurement systems, which are closely related to automation technology in the 2009 version[(1)] of this strategic technology roadmap, are described below. Information technology (IT) is described below based on the "*i*-Japan Strategy 2015[(2)]" proposed by the Japanese government's IT Strategic Headquarters.

(1) Technology strategy for energy

In the energy field, the following five policy objectives were established based on Japan's "New National Energy Strategy" formulated in 2006 and the "Cool Earth 50" plan of 2007, and major technologies that can contribute to these policy objectives were identified.

(a) Improvement of total energy efficiency
(b) Diversification of fuel for transport sector
(c) Promotion of the development and introduction of new energy
(d) Utilization of nuclear power
(e) Guarantee of a stable supply of fossil fuel, and effective and clean utilization

Category (a) can include energy-saving industrial processes (iron manufacturing, petrochemical production, etc.), and process control technology will contribute to attaining the objective of this category. Next-generation energy-saving devices made of SiC (silicon carbide) and GaN (gallium nitride), and high-efficiency inverters are also included in this category. Efficient energy management systems for homes, buildings and regional areas are common to both categories (a) and (c). Category (c) can include solar power, wind power, and biomass power, and the importance of grid interconnection technology for these distributed power sources is also indicated. Category (e) includes fuel cells, $CO_2$ collection and storage technology, and so on.

(2) Technology strategy for measurement systems

Aiming to ensure safety and security and to advance technical competitiveness, Fuji Electric aims to accelerate the development of new measurement devices and to popularize the technology for utilizing the measurement devices.

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The following items are common to both the specific challenges and representative projects involved in the research and development of hardware and software for measurement devices.

(a) Development of leading-edge measurement devices based on new sensors and new principles, and expansion to the global market
(b) Technical development for ensuring software embedding and traceability requirements according to the field user's preference
(c) Provision of measurement solutions, such as failure inspections, to manufacturing sites
(d) Measurement standards improvement, standardization activities and certification method

The most crucial technical challenges for improving gas flow measurement performance include how to achieve higher precision, reliability and speed, widen the range of gas types, ensure traceability, and so on.

(3) IT strategy

The "*i*-Japan Strategy 2015" was formulated as a new strategy that sets targets for information technology in Japan by the year 2015. This strategy aims to realize digital inclusion, in which digital technology, like air or water, is universally accepted without resistance and encompasses the entire economy and society, and digital innovation, in which digital technology and information generate new vitality by reforming the entire economy and society, in Japan by 2015. With "industrial and regional invigoration and the cultivation of new industries" as one of the three pillars of support for this strategy, measures to increase the functionality and reliability of embedded software and to reduce carbon emissions through clean IT are cited as examples of the implementation of this strategy.

### 2.2 Market and technical trends

Recent trends of global markets and technology relating to automation technology are described below.

(1) International standardization

Compliance with international standards is becoming increasingly important. Standardization in the measurement and control fields for energy and industrial processes is being advanced mainly by the TC8, TC59, TC65 and TC95 IEC Technical Committees. The trends toward digitization, networking, industrial wireless networks, and international standardization from a systems perspective are intensifying, and there is interest in technology for supporting system vertical integration, the Smart Grid, and the like. Standardization of industrial wireless technology is being advanced with the Wireless-HART standard of the HART Communication Foundation, and the SP100 standard of the ISA (International Society of Automation). With ISO 12100 (safety of machinery) and IEC 61508 (functional safety of electrical systems) as upper level standards for machinery and equipment safety, standardization is also being advanced for various industries and equipment. In Japan, JIS standards are being adopted, and as part of this trend, the introduction of safety instrumented systems is gradually becoming accepted as a common sense measure.

(2) Production and environmental technology

For energy management, the ISO 50001 standard is being advanced and aims to be released by the end 2010. ISO 50001 for energy management will provide similar standardization as ISO 9001 for quality management and ISO 14001 for environmental management. Meanwhile, environmental regulations for products, such as RoHS*1 and lead-free regulations, are also being advanced.

(3) Sensor networks

Under the guidance of the Japanese Ministry of Internal Affairs and Communications, research and development of ubiquitous sensor network technology is being carried out to realize a network in which sensors can recognize people and objects and their peripheral environments, and information can be distributed autonomously among the sensors, enabling real-time responses to situations. To realize such a network, various efforts are conducted to overcome challenges involving wireless communications, networking, MEMS (micro electro mechanical systems) sensors, sensor interfaces, and batteries (or self-generation technology), and a method to achieve long-term operation without degrading the reliability of these elements.

(4) Control technology

Since the 1990s, robust control and neural networks have been applied to the industrial and consumer fields, in household appliances, cars and the like, and coupled with advances in information technology, have had a dramatic effect. As prospective applications, the theories and methods of hybrid control for seamlessly handling continuous and discrete systems, and dependable control for realizing higher reliability, availability and safety, have recently attracted attention.

(5) Smart Grid technology

As a centerpiece of U.S. President Obama's "Green New Deal" legislation, Smart Grid technology is attracting attention. The Smart Grid is a next-generation transmission and distribution power systems, having a control system that uses IT to automatically adjust the power flow from both the supply side and the demand side. With dedicated devices and software embedded into a portion of the transmission and distribution network, the Smart Grid continuously monitors electricity and is able to achieve a good balance between power demand and supply, and is attracting attention from Europe, China, Japan and elsewhere throughout the world. Since the underlying assumptions about power infrastructure differ according to the country, there are various opinions concerning the

*1: RoHS: EU directive that restricts the use of certain hazardous substances in electrical and electronic equipment

challenges and net effect of the Smart Grid. Japan is said to be a superpower for Smart Grid element technology. With the anticipated spread of photovoltaic power generation to ordinary households and the expanded use of distributed generators, development efforts are focused on measurement sensors for the precise control of distribution systems, control technology for control terminals and next-generation distribution systems.

### 2.3 Demand trends

In the energy and environment related markets, demand in China and Asia is expected to increase. In Japan, the environmental and energy conservation related markets are forecast to grow by an average annual rate of about 8% and to reach 15 trillion yen by the year 2020. The Smart Grid related market is also growing rapidly, and reportedly is expected to reach US$20 billion in size by the year 2014. Demand for safety and security is expected to increase in the Middle East and in Asian regions such as China and India, and a high growth rate of approximately 10% is forecast. The markets related to environment, energy conservation, safety and security are expected to continue to grow both in Japan and overseas, and automation will play a significant role in that market growth.

## 3. Fuji Electric's Vision for its Automation Business

### 3.1 Customer issues and needs

Especially due to changes in the business environment of manufacturers, customer issues and needs have changed as follows.

(1) Support of a global manufacturing environment

The manufacturing industry must be able to supply products in a timely manner to the required markets. Manufacturers are therefore establishing manufacturing sites near to their desired markets, and are consolidating their manufacturing sites at countries and regions where labor and other costs are low. Meanwhile, technology for the integrated management of distributed sites, global supply chain management, security, intellectual property protection and the like has become critical.

Moreover, since the employees at these distributed sites will have different cultural backgrounds, work standardization, work history management, and a higher level of safety design for field equipment are being requested more than ever.

(2) Optimization of asset utilization

A manufacturing system capable of responding flexible to fluctuations in demand, business climates and exchange rates, changing needs and other market risks, and the ability to construct, modify and relocate manufacturing sites and production lines quickly and with low cost is essential. As a result, equipment is trending to become modularized, generalized and portable.

In response, global simulations that include simulations of the distribution among multiple sites, precise simulations of manufacturing processes, wire-saving and wireless field devices, and devices having plug-and-play functionality that enables operation just by connecting the equipment are requested.

(3) Investment risk reduction (high utilization rate, improved safety) and product safety

Field equipment is requested to provide increasingly higher utilization rates, and in the case of an accident or equipment breakdown, the operation shut down time and opportunity loss must be minimized. Accordingly, high reliability and safety are requested and the capability for early detection and future prediction of abnormal symptoms is anticipated so that countermeasures can be implemented prior to a breakdown. In addition to the conventional level of reliability, dependable design technology is also sought to improve system availability, enhance resistance to breakdown, and so on.

The ensuring of product safety is a principal risk that, without mentioning specific cases, may affect the continuing existence of a company. Particularly in the case of food, drugs and the like, the removal of defective products, more sophisticated inspections to detect contamination with foreign matter, microorganisms and the like, and guaranteed traceability from raw materials to manufacture and distribution are requested.

(4) Mobility of human resources and retention of the skills

The generation of baby boomers is approaching retirement age, and the workforce is becoming more mobile. The ratio of temporary employees to regular employees is increasing, in order to be able to respond flexibly to changes in material resources due to the fluctuations in the business climate and so on,. Further, there is a shortage of younger workers, not only in Europe and the US, but also in Japan. Foreign employees in these countries are being hired in increasing numbers as a result of globalization.

Consequently, there is a need for work tasks to be simplified so that an employee may engage in the work after only a short-term training course and for safe equipment and devices that can be easily operated even by non-experts. Providing the equipment with intelligence such as self-diagnosis and functional safety capabilities gives support to the workers. Additionally, the capability to monitor the health and conscious state of workers in order to ensure safety is also requested.

(5) Support of eco-friendly society

As one solution for mitigating the impact of global warming and achieving zero emissions, support for an electric vehicle (EV)-oriented society is requested. For this purpose, devices must be made to consume less power and to be smaller in size, and their operating efficiencies must be monitored and improved regularly.

Moreover, in support of the regulation of harmful substances (Air Pollution Control Act, Water Quality Pollution Control Act, RoHS, REACH*2, etc.), the low concentrations and small quantities of harmful substance components in flue gas and waste water emissions from business establishments must be measured. Challenges to the realization of an EV-oriented society include the development of safe and highly efficient drive control technology and the provision of an infrastructure that includes rapid charging stations.

### 3.2 Three key concepts

Figure 1 illustrates the progress of devices used to configure automation systems, with the horizontal axis showing the I/O processing speed and the vertical axis showing the memory capacity installed in the devices. Electronic technology and software technology have exhibited rapid progress, and the changes in system configuration have been remarkable.

*2: REACH: EU regulation concerning the registration, evaluation, authorization and restriction of chemical substances

Figure 2 shows Fuji Electric's automation business activities. As shown in the top of this figure, accompanying the distribution of risk and the increasing sophistication of functions, the constituent devices

Fig.1 Automation system constituent devices and technical progress

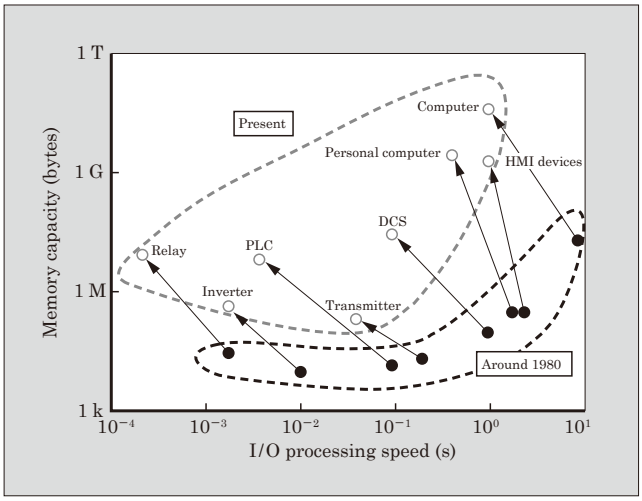
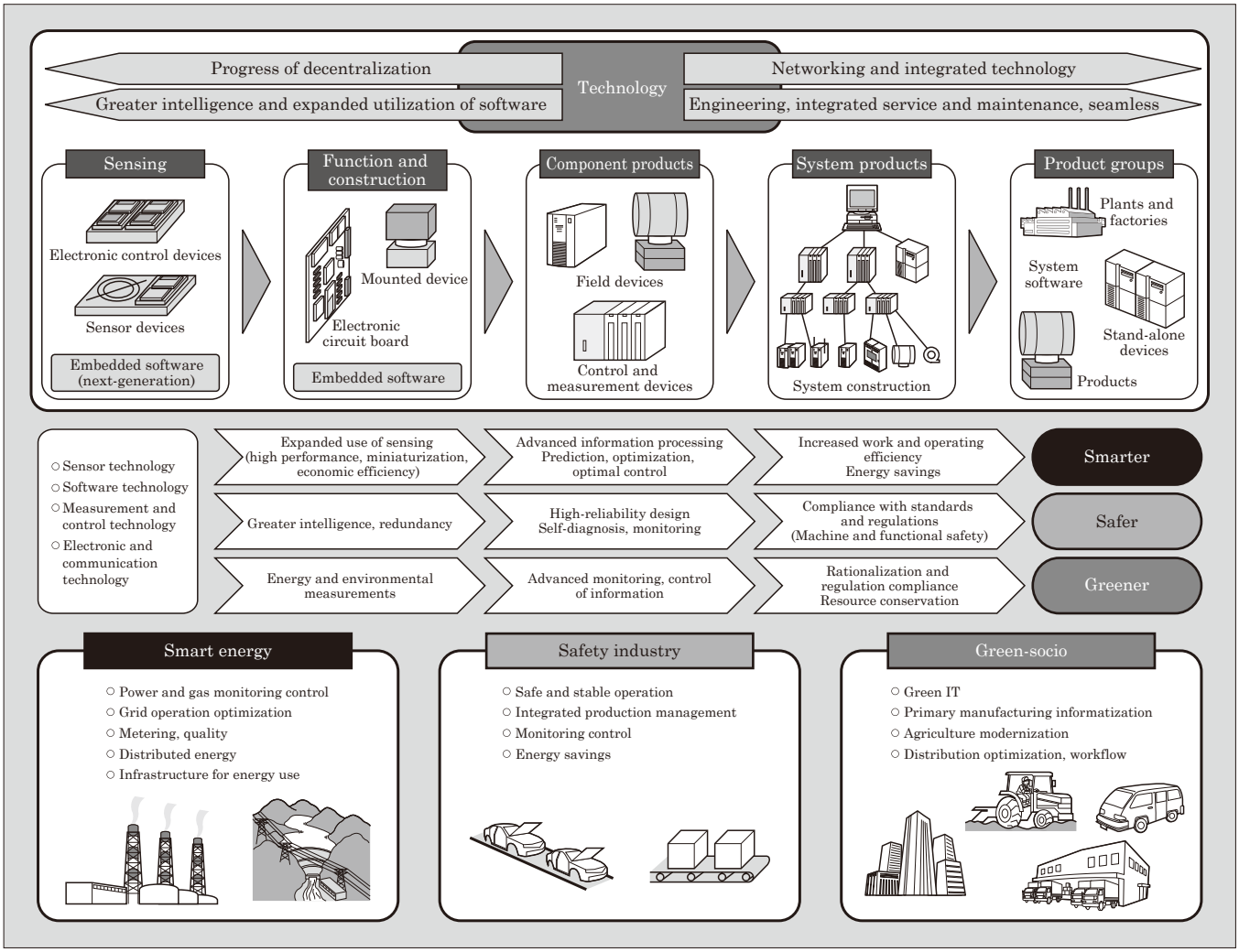



Fig.2 Fuji Electric's automation business activities



have become more physically dispersed and autonomous. Meanwhile, from the perspectives of operation and engineering services, a seamlessly integrated environment is requested. The future of automation is in solutions that contribute to improved economic competitiveness by "increasing the visibility" of processes and manufacturing and by "increasing the comfort and safety" of operation. With this aim, from sensors to system construction, Fuji Electric is advancing technical development and the commercialization of products based on the key concepts of (i) smarter, (ii) safer and (iii) greener technology.

Smarter technology means higher performance sensing, advanced information processing such as optimization, higher efficiency for work and operations, and energy savings. Safer technology ensures safety and security by providing high-reliability redundant systems, high-reliability designs and safe designs, functional safety systems that conform to international standards, and the like. Greener technology supports the environment with environmental load measurement, sophisticated monitoring, support of environmental regulations, resource conservation, and so on.

Business fields are categorized into the energy field, which includes electric power, gas, oil, etc., the industry field, which includes food, chemicals, iron/steel, electrical machinery, machinery, etc., and the "socio" field, which includes agriculture, distribution, services, commerce, public utilities, etc. The above-mentioned three key concepts are important to each of these three fields, and technical development is being advanced with particular emphasis on smarter technology in the energy field, safer technology in the industry field, and greener technology in the "socio" field.

### 3.3 Fuji Electric's activities for automation technology

(1) Safety technology

Fuji Electric has long been engaged in efforts to increase the reliability of plant safety control systems for power utilities, public utilities, factories and the like, and has also been involved in many efforts including plant and device fault diagnosis based on sensor technology. Fuji Electric has also achieved many successful results with security management for information control systems and the like. Additionally, Fuji Electric is stepping up efforts to train engineers and provide products so as to comply with standards and regulations for safety of machinery and functional safety. In all its products, Fuji Electric endeavors to incorporate safety system design principles based on risk assessment and on development using safety techniques that conform to international standards.

(2) Platform development

Previously, development was performed uniquely according to the industry sector, organizational structure and type of equipment, and as a result, the development period would be prolonged, and technology would stagnate and efficiency would decrease due to the individual development. Therefore, Fuji Electric is moving ahead with efforts to establish a common platform (cross-sectional development and establishment of infrastructure technology) that would provide a technical foundation. The establishment of a platform enables development processes and technology to be shared and standardized, software and hardware components to be standardized, and efforts to develop leading edge technology to be shared and the technology accumulated. Consequently, the development period can be shortened, technical sophistication enhanced, and quality improved.

(3) Embedded system technology

Software is embedded in all sorts of electronic devices. Moreover, as the scale of development work continues to increase, it is important that the development work be more efficient and result in higher quality products. For this purpose, hardware and software platforms have also been established for embedded systems, and the standardization and modularization of development techniques and development processes are being advanced.

(4) 3R engineering

Fuji Electric is advancing the use of common platforms for software development and for engineering work involving the controller, computer and HMI (human machine interface) devices that configure a control system, and the use of an integrated engineering environment to improve work efficiency. The result promotes the reducing of design and development work, the reusing of design assets, and the recycling of components. Fuji Electric calls this 3R (Reduce, Reuse, Recycle) engineering.

(5) Control technology

Control technology is the core technology for realizing optimization and prediction and diagnosis capabilities in order to improve the energy savings and safety of devices and plants, and Fuji Electric has long been involved in this core technology. By engaging in efforts to establish platforms for single-input-single-output PID control and multivariable model predictive control, and to train control engineers, Fuji Electric aims to raise the level of applied technology. Fuji Electric is also heavily involved in non-linear optimization technology and multi-variable statistical process control technology.

(6) MEMS and sensor technology

It is important that the sensors and actuators used to configure a control system are themselves power-saving and resource-saving type, and the use of MEMS (micro electrical mechanical systems) devices that integrate electrical circuits and mechanical systems are an effective means for realizing the desired power and resource savings. Fuji Electric has been involved with MEMS technology for more than 20 years, and the application of MEMS technology to measurement devices, radiation sensors, gas analysis sensors and the like has contributed greatly to their miniaturization and

the realization of power savings. Fuji Electric has recently been developing a methane gas sensor housed in a gas alarm device for detecting gas leaks, and a vibration sensor for detecting abnormalities and abnormal symptoms and for diagnosing the soundness of equipment, buildings and the like.

(7) Network technology, wireless technology

For control system networks, Fuji Electric is advancing development to realize a mechanism for transmitting information at the network level, targeting vertical integration of the engineering environment that extends from the field devices to the controller and up to the computer. Specifically, Fuji Electric is advancing the application of Ethernet/IP at the controller level and FDT/DTM (field device tool/device type manager) technology for integrated engineering.

For wireless technology, Fuji Electric is promoting the establishment of a wireless platform for specified low-power radio waves for short distances and a mesh network for wide areas. At the same time, Fuji Electric is attempting to reduce communication trouble by standardizing the engineering technology for wireless networks and using interference avoidance technology.

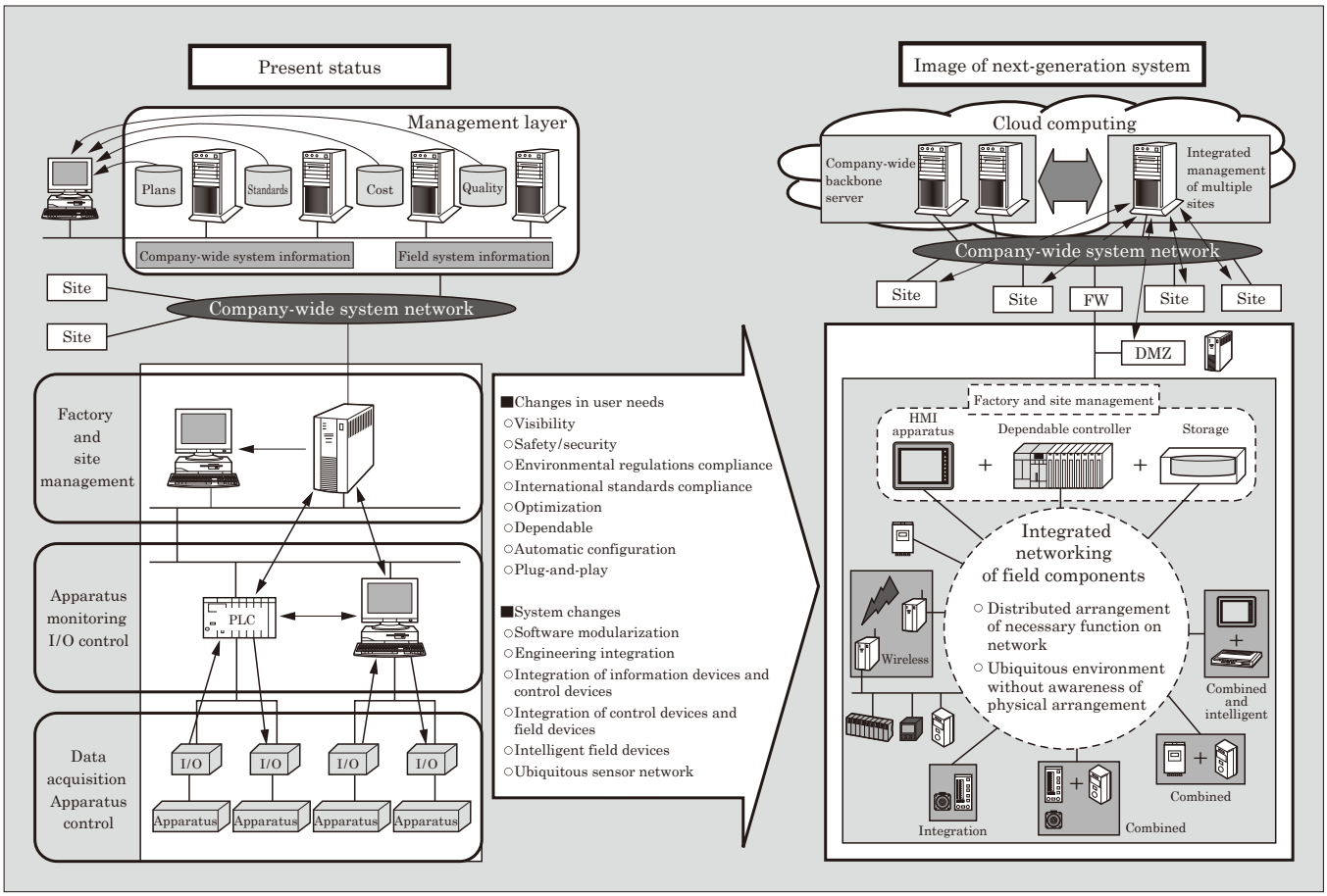
## 4. Future Outlook

Entrusted by the Japanese Ministry of Economy, Trade and Industry, the relevant associations met in 2008 to discuss future visions for cross-sectional scholarship, and for four topics, prepared an academic road map[3] targeting the years 2010 to 2040. In this work, WG1 (control and management engineering field) listed the construction of a safe and secure society and an approach to environmental problems as the most important needs, and the technology of "increasingly complicated objects and increasingly complicated systems" as seeds for future development. To understand, analyze and control these seeds for development, it is said that the status of objects and systems must be monitored at various levels and made "visible."

However, visualization is not simply the same as "measuring," and also includes data "consolidation" and "presentation." These three elements are important, and visualization technology must evolve while maintaining the close relationship between these elements.

In reference to the above and based on current needs and the progress of information control technology, an example implementation of the imminent next-generation automation system conceived by Fuji

Fig.3 Configuration of next-generation automation system



Electric is shown in Fig. 3.

## 5. Postscript

Based on Japan's technology strategy and trends of the global market and technology, Fuji Electric's activities and outlook for its automation business and technology have been described. To mitigate global warming, the total greenhouse gas emissions worldwide, converted into the corresponding $CO_2$ emissions, must be cut by at least 50% of year 1990 levels by year 2050. To realize this goal while maintaining our lifestyle will require various measures and policies, and the potential for automation technology to contribute to the attainment of this goal is extremely large. Automation technology also holds many promises for ensuring the safety and security of society.

Positioning its business around "Energy and Environment," Fuji Electric intends to provide automation technology as a cornerstone for the realization of a safe, secure and sustainable society.

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