Driving Innovation for Supporting the Social Infrastructure of a Sustainable Society

Toshiaki Shirai *1

Yokogawa has a mission to supply products and solutions supporting the industrial social infrastructure, and aims to create businesses contributing to achieving a sustainable society from a long-term perspective, based on its core competencies of measurement, control and information. Through studying social megatrends, Yokogawa recognizes that harmonizing machine and human systems and helping to enhance human capability are promising directions for its R&D. Yokogawa sets an innovation vision in line with the above observations, and plans to create new technologies and markets contributing to achieving the goal.

INTRODUCTION

In accordance with the Yokogawa philosophy, "As a company, our goal is to contribute to society through broad-ranging activities in the areas of measurement, control and information," Yokogawa places great importance on continuously providing excellent products and solutions in areas related to industrial social infrastructure. Because the target business markets of Yokogawa are those of industrial social infrastructure, where significant social responsibility is required, Yokogawa recognizes that the medium to long-term perspective is important in its research and development, without being needlessly affected by short-term economic fluctuations or momentary trends. In these days in which industrial structure is drastically changing, innovation creating new markets and technologies which can bring about discontinuous transformation are required.

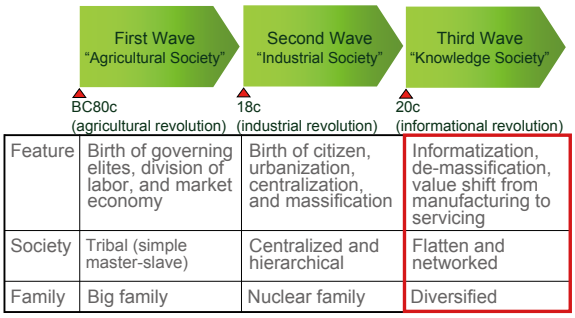
This paper introduces Yokogawa's innovation vision, and its initiatives for achieving its goal.

CHANGES IN INDUSTRIAL STRUCTURE AND EXPECTATIONS FOR INNOVATION

When considering the changes in industrial structure, merely pursuing short-term political and economical trends can lead to misidentification of future changes. In order to foresee significant changes in terms of periods of a decade, it is important to understand major global social changes referred to as 'megatrends'.

One notable megatrend is the transition from an industrial society to a knowledge society, which started in the late 20th century shown in Figure 1 [1]. In industrial society, the source of wealth lies in the production of industrial goods, and larger-scale and more centralized production is intended to improve productivity. Mass consumption of high quality and homogeneous products has increased the wealth of the society.

However, as information utilization pervaded society after the information revolution at the end of the twentieth century, mass-produced goods alone could no longer satisfy society demands due to the diversification of users' needs. As a result, a shifting away from large-scale production began, and small lot production of many products and even individual production satisfying each user's requirements then came to be demanded. As for consumption, major concerns for the value of goods have shifted from products themselves to their usage, i.e. services. In other words, the source of wealth has been shifting from tangible production to intangible properties, including use of products- that is, knowledge.



Feature	Birth of governing elites, division of labor, and market economy	Birth of citizen, urbanization, centralization, and massification	Informatization, de-massification, value shift from manufacturing to servicing
Society	Tribal (simple master-slave)	Centralized and hierarchical	Flatten and networked
Family	Big family	Nuclear family	Diversified

Figure 1 From an industrial society to a knowledge society

Another notable megatrend is the growing interest in sustainable societies. Emissions of greenhouse gases such as carbon dioxide have been increasing from year to year, and especially in recent years, increases in amounts of emissions in newly industrializing countries including China are remarkable. As global warming is steadily progressing, reducing greenhouse gases which are considered to be the

*1 Innovation Headquarters

cause of global warming is now a global common concern [2]. Limitations of natural resources and energy are urgent issues from the standpoint not only of environmental protection but also social economy. Aiming for sustainable growth without falling into shrinking equilibrium through effective use of limited resources is required.

Meanwhile, as emphasized after the Great East Japan Earthquake and the Fukushima nuclear accident, the ability to deal with what are called incidents beyond expectations which exceed technological hypotheses is an issue. While examining the future using megatrends is based on conclusive forecasts, by extrapolation from historical facts, incidents beyond expectations have nothing to do with probability.

Incidents beyond expectations can be triggered not only by causes beyond the scope of human intellect such as natural disasters, but also by causes inherent in systems in a society characterized by increased complexity. It is said that incidents beyond expectations tend to occur when systems are too complex, or else when the gaps among the complexities of multiple systems are significant [3].

To reduce the risk of the occurrences of incidents beyond expectations, adaptability, redundancy and resilience are required. Adaptability and redundancy are well-known concepts, and essential in particular for industrial control systems. Resilience, the third requirement, is originally a psychological term, and means the ability to survive by flexibly adapting to situations even during difficulties. In recent years, this concept has been gaining in significance in industrial social systems by improving risk management capability for the mitigation of effects of fatal failure caused by incidents beyond expectations.

In a society of ever increasing complexity, it is difficult to predict a future in which uncertainty is an inherent probability. The speed of social change is definitely increasing daily. This change is sometimes accompanied by discontinuity, making it difficult for existing technologies or extension of the existing industry structure to cope with the change. For this reason, innovation aiming to resolve social issues of discontinuity is to be expected. This innovation does not imply merely technical transformation, but also transformation in every area of social and industrial activities.

INSIGHT INTO THE FUTURE AND THE CONTRIBUTION OF YOKOGAWA

Yokogawa has been adopting a scenario planning approach to verifying possible future situations. One scenario planning feature is that it assumes the future to be uncertain and therefore does not aim at assertive forecasts, but rather provides multiple possible situations as future scenarios. Such scenario planning has been adopted by several companies for establishing their medium to long-term business strategies, etc. [4].

We have selected two parameter axes considered to have critical impact on the future and drawn four future scenarios in the four quadrants resulting from those axes. Figure 2 shows the four future scenarios currently defined. The scope is a future vision of the process industry, the main business area of Yokogawa, at a time of about ten years later. For the parameter axes dividing the quadrants, a macro-shift of sources of revenues in the process industry is taken as the horizontal axis, and the level of global commitment to sustainability is taken as the vertical axis.

The quadrants are horizontally categorized in a manner as to whether revenues are still generated from products, or if the main source of revenues is pursued in services in a broad sense. This categorization corresponds to the megatrends explained in the previous section indicating the transition from an industrial society to a knowledge society. The shift of the main source of revenues to services means that providing intangible values such as knowledge and management capability come to be the core activities in business. Meanwhile, this implies changes for manufacturers.

On the other hand, the quadrants are vertically categorized in a manner as to whether a global consensus on environmental regulations exists so that the prevention of global warming is established, or if the current situation where regulations are not consolidated is continued as is now. This categorization corresponds to the megatrends explained in the previous section indicating the transition from a consumer society to a sustainable society. In a case where most countries agree with measures for reducing the environmental burden under international pressure resulting from serious environmental destruction caused by emerging nations or others, it is expected that industries will actively undertake a challenge to innovate their industrial structures while considering the situation as a business risk. Public and private investment in business areas which contribute to improving sustainability is expected to increase. Meanwhile, even in the case where consolidated international consensus cannot be reached, unlimited growth of production and consumption cannot continue due to the limitations of natural resources and energy, so that growth is expected to stop before long.

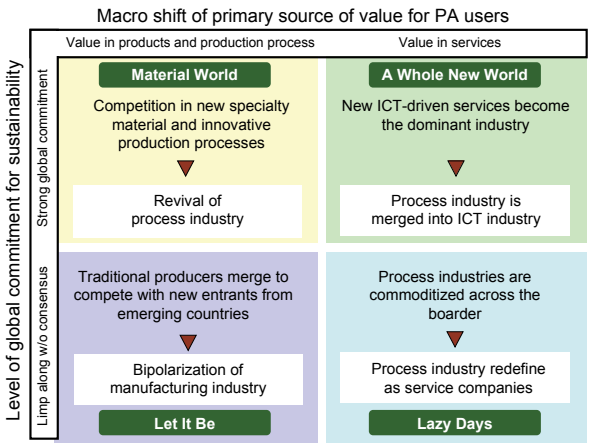


Figure 2 Future scenarios

Because the parameters for categorizing scenarios are derived from existing knowledge such as megatrends or industry-specific knowledge, future scenarios obtained

through scenario planning shape a view of the world that is restricted by the particular framework. Occurrence of incidents beyond usual expertise is actually inevitable, and so a resilient response to it is essential. In order to catch signals of changes impacting on Yokogawa's business early on, we have also introduced a method called scanning, consisting of studying situations as widely as possible.

As shown in Figure 3, scanning is performed by repeating a series of workshop sessions. During the first session, to share their viewpoints, participants discuss assumptions in their areas of interest, and clarify issues and uncertainties. During the second and third sessions, participants bring signals of changes obtained through daily observation, extract causes triggering changes, and estimate the degrees of impacts and their resulting effects. During the fourth session, on the basis of the issues, the signals of changes and the resulting effects obtained in the previous sessions, potential domains in the areas of interest where future innovation is expected are derived.

The search for future possibilities by the use of future scenarios and the detection of signals of changes by the use of scanning are continually being carried out, making use of our network consisting of internal and external experts throughout the world including researchers, academics and industry intellectuals. Through these activities, we are able to renew our awareness of our future business environment and related issues. In addition, as the result of this activity, we are able to arrive at the consensus towards the future that global issues cannot be resolved without innovation in human behaviors. Whatever future is supposed, it is impossible to avoid expanding the gap caused by deficiency or uneven distribution of natural resources, energy, water and food. No technological innovations can offer a complete solution to overcoming these physical limitations. Instead, it has been pointed out that issues can be converted into opportunities by changing human consciousness and behavioral patterns.

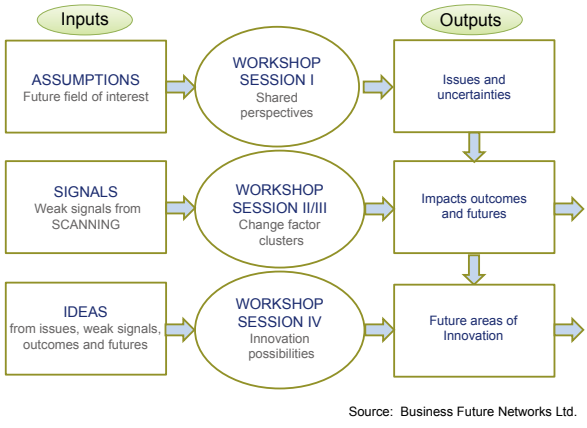


Figure 3 Scanning

For example, people of today enjoy lifestyles allowing them the feeling of affluence, owning cars, consuming fuel and travelling far. As long as this kind of lifestyle is maintained, advancing global warming cannot be stopped, and it will be only a matter of time until we are faced with the exhaustion of resources and energy. However, if we change our way of thinking from owning cars to using public transportation, the situation will change. If a framework for sharing cars in a community is introduced and a highly self-sufficient and compact urban environment is established, the significance of the resource and energy problem will greatly decrease. This cannot be achieved by technological innovation alone, but inevitably requires innovation in the consciousness and behavior of the people involved.

Innovations in human consciousness and behavior will significantly change the definition of affluence, and can lead from insufficiency being considered as a problem to it being a source which creates new wealth, health and happiness. Because human beings tend to hope to maintain their status quo, technological support and incentives are essential for innovations in human consciousness and behavior. To respond to this situation, discontinuous innovation is to be expected. The innovation that encourages innovation in human consciousness and behavior is that which is from a unique viewpoint for motivating new technology creation. Furthermore, innovation in human consciousness and behavior are expected to create new industries contributing to achieving sustainable societies.

Yokogawa is confident in having advantages of fundamental technologies supporting industrial social infrastructures, owing to long experience in the area of industrial automation. Yokogawa has also advantages over mission critical application areas, where no instantaneous interruption of system operations is allowed. We believe that innovation making the most of Yokogawa's core competences will greatly contribute to the innovation in behavior and consciousness of people involved in social infrastructure systems.

INNOVATION VISION: REMAKE HUMAN WORK

Traditional automation aimed at automating by control devices and information systems- ultimately at unmanned operations. This approach may often cause dehumanization in manufacturing. Meanwhile, the term 'automation' is originally defined as "productivity enhancement in production or service provision by making use of mechanical, control, and information technologies." Understanding this definition literally, automation aims to achieve high productivity or high quality that cannot be attained by manual operations alone, and does not aim to replace human beings with machines nor exclude human beings.

Human capability is extremely wide-ranging, and is characterized by abilities impossible for mechanical systems to perform: to provide a holistic view and to integrate complex systems. A more advanced system can be constructed by making full use of human capability while centering human beings in the system rather than by attempting automation with machines alone. Human decision making can be assisted, for example, by providing them with perception capability beyond human senses and analysis capability of enormous

and wide-ranging information data beyond human processing capability, and by instantly indicating to them choices which human beings cannot easily call to mind.

Through studying insight into the future described in the previous section, we have come to the conclusion that innovation relating to the innovation in human behavior, including that in human consciousness, is the key to the future. That is, not only providing systems that merely assist human beings, but also creating technologies and markets which encourage the innovation in consciousness of people involved in the systems, and bringing forth the innovation in human behavior required for achieving the sustainable societies that are demanded. To lead this new type of innovation, we have declared the phrase "Remake Human Work" as the innovation vision of Yokogawa, with the hope of bringing about changes in human behavior.

The cooperative system of human beings and machines which Remake Human Work is aiming at will be spontaneously equipped with capability to flexibly respond to the environment surrounding human beings, and to contribute to improving resilience of the systems.

In developed countries including Japan, decreases in the labor population caused by the decreasing birth rate and aging population are now of great concern. Successive retirement of experienced technicians and engineers at production sites creates a major problem for transferring techniques and skills. A system which expands and assists human capability indirectly supports limited valuable human resources for manufacturing, and maximizes the value produced by them. On the other hand, in newly industrialized countries, supplying skilled technicians and engineers cannot keep up with expanding production demand, and so the system which expands and assists human capability is also required just as in developed countries.

INNOVATION THROUGH CO-CREATION

Innovation encouraging social innovation and creating new business opportunities cannot be achieved only by technological development. We have defined three stages for processes to create innovation as shown in Figure 4.

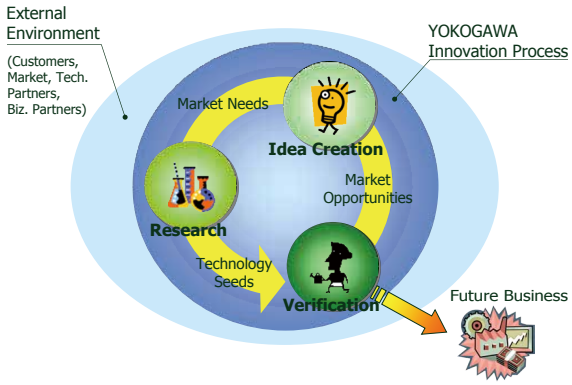


Figure 4 Co-creative innovation processes

The first stage is for creating ideas. Inputting on-site information from markets and customers and signals of changes derived from scanning or others, ideas which are the seeds for innovation, are extracted. The diversity of ideas is expanded through examination by internal and external knowledgeable persons, and the ideas are settled upon as challenging themes for meeting the corporate strategy.

The second stage is for research and development. In this stage, the market needs obtained in the idea creation stage are implemented as specific technical results. Research and development are conducted while seeking peripheral technologies which complement Yokogawa's core technologies from external partners without falling into a so-called 'not invented here' (NIH) syndrome, and joint research and business development are performed.

The third stage is for verification in the market. In order to complete the results of research as products, commercialize them, and finally make their business profitable, verification in their specific markets is indispensable. Not only conventional verification in the market starting at the final stage of the research and development phase, but also collaboration with potential customers from the early stages of the research and development phase are performed so that feasibility is judged earlier.

These three stages are not supposed to be applied sequentially in the order described above. This process aims at a spiral improvement in output at each stage, and can start from any stage and repeat any stages in arbitrary order depending on each case. During each stage, collaboration with global innovation partners both inside and outside the company is proceeded with under the concept of co-creation. Under the vision of Remake Human Work, Yokogawa will enhance the motivation of people involved in production and services, and create innovation also contributing to a transformation in human consciousness.

CONCLUSION

Through studying insight into the future, global common issues beyond countries and regions are found. Although the extent of the contribution to resolving such issues by a single company is limited, we recognize that challenging issues from a broader point of view aiming at a highly set goal is an important activity for a company aiming at its sustainable development. As a company with the core competence in measurement, control and information, Yokogawa will contribute to achieving a resilient and sustainable society through innovation based on a focused vision.

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