# System design management and *Synthesiology*

## — Methodology to tackle the issues of modern society and to utilize the research results in society —

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The Graduate School of System Design and Management, Keio University was established in 2008. This school aims to create a comprehensive and integrated discipline that offers creative solutions to various issues in our society. Since their way of thinking is instructive for *Synthesiology*, a journal that seeks synthetic methodology for disseminating the research results into society, we discussed some common interests and ways of collaboration in the future.

***Synthesiology* Editorial Board**

### Participants of the round-table talk

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| **Takashi MAENO** | Professor, Graduate School of System Design and Management, Keio University |
| **Hidekazu NISHIMURA** | Professor, Graduate School of System Design and Management, Keio University |
| **Ken'ichi TAKANO** | Professor, Graduate School of System Design and Management, Keio University |
| **Naohiko KOHTAKE** | Associate Professor, Graduate School of System Design and Management, Keio University |
| **Hideyuki NAKASHIMA** | President, Future University Hakodate |

< Editors in charge of dissemination of *Synthesiology*>

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| **Motoyuki AKAMATSU** | AIST |
| **Naoto KOBAYASHI** | Waseda University |

### Kobayashi

Because the Graduate School of System Design and Management (SDM), Keio University was established in 2008, and *Synthesiology* was launched in the same year, we feel a special connection. I have heard that SDM aims to understand the social issues systematically, to analyze them, and to creatively design the solutions. I think this way of thinking has something in common with the objectives of *Synthesiology*. Now, Prof. Maeno, can you start by explaining the characteristics of the SDM education and research activities?

## Tackle the issues of modern society by practice of overarching integrated discipline

### Maeno

The conventional disciplines focused on specific fields and analyses, and were separated into individual compartments. However, in modern society, everything has become large-scale and complex, and this is causing numerous problems. Even if one has a core specialty, that alone cannot solve problems. A rocket cannot be created by mechanical engineering alone, nor can a policy be formulated with the discipline of economics or law alone. Therefore, SDM was established to create a new interdisciplinary study that can integrate the disciplines based on the demands of society.

Although there are graduates fresh out of college at SDM, the majority of our students have work experience, and people who already have their specialties can learn here. First, we thought there would be many engineers, but it became a gathering place of people with diverse backgrounds including marketing consultants, artists, business managers, university professors, and others. This is one characteristic. The second characteristic is the creation of the discipline of SDM that integrates diverse research domains, and people of diverse backgrounds speaking a common language. That's our new attempt.

One of the cores of SDM is "systems engineering." In Japan, system engineering tends to be seen in its narrow sense of IT engineering, but actually it has recently been defined as a discipline for interdisciplinary problem solving. In our education, system engineering is expanded into research of social systems.

Another core is "design thinking." This originated from Stanford University and IDEO, and it is a discipline for creating something new from scratch by innovative co-creation. It is a discipline for "thinking as you make" and "go ahead and fail rather than receiving proper evaluation," and therefore, it has been thought incompatible with engineering. I think our characteristic is to do both. This means we somehow integrate the development of large-scale systems through systems engineering and the activities for innovative and free creations.

I think our goal is similar to *Synthesiology*. However, we use the word "system." The difference between "system" and "synthesis" is, "system" includes the meanings of "to synthesize" and "to break down systematically," and it takes the stance of doing both synthesiology as well as conventional studies. By doing both, the "parts" and the "whole" can be designed. Through the unique method of SDM studies, we fill in the conventional, so-called "valley of death" research areas just as in synthesiology.

### Nakashima

The word "synthesiology" emphasizes synthesis, but I think we need both analysis and synthesis. To synthesize, it is necessary to analyze after something is made as well as analyze before making.

## How to seek out the social issues

### Kobayashi

One of the methods of synthesiology is: to set a clear social goal, to create a scenario by backtracking from the goal, to synthesize the elemental technologies according to the scenario, to provide feedback after social test run and evaluation, and then to further elaborate the scenario. In case of SDM, do the students themselves decide, "I want to set this subject as the social goal"?

### Maeno

In systems engineering, the initial requirement analysis of the V model, and in design thinking, the activities of design thinking itself correspond to the setting of issues and goals. It is the phase of going out into the field and capturing the demand of society, and it is indeed the entrance of both disciplines. We are putting plenty of emphasis here in our education and research.

### Kobayashi

We use the phrase "problem-solving type," but it seems extremely difficult for the students or researchers to go out and find the problems.

### Maeno

It is difficult, but it is the point on which we must spend our maximum effort. Speaking in the context of design thinking, I think it is important to do fieldwork such as participant observation (ethnography) to jump in and to contemplate the world, to understand the world by appreciating other people's ideas as diverse people gather in lively brainstorming, and to understand the world by making various prototypes and having the people of the world see it.

It is "co-creation" rather than staying in the framework of academia. By working together with people of various fields and society, time is spent to clarify what competence one has and what should be set as the goal. In the prerequisite course called "design project," this part is structuralized in the first half of the course where the student spends effort to fine-tune the goal. The "why" is visualized through various methods such as a thorough modeling of society.

### Nakashima

Thinking in terms of information systems, I feel that the "technology" and "goal" of system design are two sides of the same coin. A dream is useless unless it is realizable. Things cannot be realized without the supporting technology. In that sense, the goal and technology must form a loop in which we go from one end to the other, and then come back. It's also related to Prof. Kobayashi's previous question. Although information researchers can think of all sorts of goals because they've got plenty of technology, what is a truly good goal? When you ask this question, it must be considered together with sociology to be successful. However, there are many people who do social analysis, but there are few who do social design. In that sense, I am very interested in SDM.

### Maeno

It is exactly as you say. We present the solution to a problem using the V model. We require the humanities students to learn research in the form of design and verification of systems. Inversely, the science students must thoroughly learn to clarify the social goal.

### Nishimura

I think the expression "in systems engineering" narrows things slightly. Therefore, speaking of the social goal for SDM, it is difficult to set the goal. When we do workshops copying the Future Center, for example, and say, "let us discuss the energy problem" or "how should regional mobility be," we'll never be able to reach a conclusion even

**Dr. Takashi Maeno**

after two or three hours of discussion. It doesn't necessarily mean that the goal can be set if we spend more time. If we have to set a goal, it is necessary to academically study how to set the goal. Yet, we can't start anything unless we decide on something. Therefore, in educating our students, we show, in some kind of form, how things may progress once the goal is set and actions are taken toward achieving it, and get feedback. If we say, "Failure is not allowed," nothing will move, so we say any action can be taken during a certain period, and then we move on.

**Kobayashi**
An abductive inference, being the third-type inference that is different from either deduction or induction is, important. Here, the hypothesis must be formed, and the ability to formulate a hypothesis is important.

**Takano**
I am working mainly in the field of social science, and I think the primary key point of research is "how to form the hypothesis," as you mentioned. The problem definition starts with "it really should be so." However, there is a gap with the real situation. Because the problems are complexly correlated with many issues in the modern society, one may fix an overview in a certain domain by following a certain process if one can analyze and identify the overall structure of the problem, such as this problem is affected by this issue and therefore the result is leading to this way. After gaining the overview, although it is impossible to solve all the problems that are complexly intertwined, the student can concentrate on the domain in which he/she can pragmatically and empirically research during two years. The student then forms a hypothesis and sees whether the hypothesis is correct using the social science methods such as questionnaires, ethnography, or interviews.

I mainly use the questionnaire surveys and apply the covariance structure analysis to see whether there is a cause-effect relationship as stated in the hypothesis. By doing this analysis, new cause-effects and new perspectives arise, and I think this generates possibilities that may lead to new problem solution. If one finds the cause-effect of a problem, one must make some proposals. In shaping the proposal into specific projects, the collaboration with companies become necessary, and I feel that verification cannot be achieved unless a long-term view is taken.

**Dr. Hidekazu Nishimura**

## Verification and validation of research

**Kobayashi**
Yes, I think a lot of time is needed when we try to take research all the way to verification. How about the methodology, Dr. Akamatsu?

**Akamatsu**
From the discussions so far, because the activities of SDM lies on the side of real society, verification might be difficult. I think it is impossible to evaluate without bias to see whether a problem had been solved. If it is mere technology, the verification is somewhat easier. But if it is about whether the technology is truly being used in society, we must evaluate how the technology is positioned in society. In natural science, we have no method for verification in a non-stationary society.

**Takano**
There is irreversibility in the social phenomenon. For example, we cannot compare under completely same conditions the situation in which action A was taken or not taken. It cannot be verified that there was no other factor involved, and that makes sufficient verification impossible.

**Akamatsu**
That is true. I'd like to ask a question. Although natural science type verification is impossible, a student works on a project at SDM and says, "This worked!" or "This didn't go well." To do so, there must be some kind of evaluation or decision involved. From what perspective do you evaluate?

**Maeno**
Our research theme is to "think of things as systems," and so, it's diverse. The case of a technological system such as, for example, the verification of whether a human-machine interface works properly can be done with clarity. On the other hand, we had a student research the "design of negotiation for world peace," but complete verification is not possible for such a topic. However, we instruct the students to do research from the perspective of creating some sort of system design, doing some kind of verification, and executing both verification (do the right thing) and validation (do the thing right) as much as possible.

I think good research is to design a clear, novel system regardless of the theme or scale, and to conduct verification and validation. In case of a system that has been narrowed down, the verification can be done clearly, and the student who engages in such research is questioned about the novelty of the system to check whether it is not merely nitpicking.

On the other hand, the student who takes on a large and ambiguous system like the research of peace or happiness must conduct the research as systematically as possible, by clearly stating the basic concept and then engaging in questionnaires, interviews and multivariable analysis. I think good research is when one knows what can be verified and what cannot be verified.

### Takano

Since two years is a limited time, it may be difficult to verify the proposal. Therefore, I think it is necessary to carry on the research to the following generation of the laboratory. The hypothesis is formed, verified, and a proposal is made. It is verified over the next two years before the final evaluation is made. If such continuity at the lab is guaranteed to some degree, I think verification can be done in a large, continuous flow.

### Maeno

You mean the students engage in small verifications, while actually being part of a greater verification?

### Takano

Yes. Like accumulating and stacking the V. That's the idea.

### Kohtake

In the social system, a behavior does not necessarily reoccur, and it is more difficult to clarify what is the boundary of the system compared to a technological system, and I think it is important to be aware of this limitation. When the students conduct verification, I tell them to work with hands and heads after firmly understanding what the range of verification is, which methods are used, and why these methods are applied. The assumption is that not everything can be included as subjects, but the verification may be possible if the definitions are set solidly. To have them understand that there are various verifications other than actually running the system, I think that is the value of being at the graduate school for two years.

## Methodology of synthetic research

### Kobayashi

On synthesiology, Prof. Nakashima wrote an article "Discipline of constructive research fields: toward formalization of 'synthesiology'" in Volume 1. May I ask you to introduce it?

### Nakashima

My research theme is artificial intelligence (AI), and I am very interested in situatedness or dependence on the environment of human behavior. When we represent a piece of knowledge as a rule, there are many cases that do not match the expression. This is the frame problem often addressed in AI. Simply taking out a piece of knowledge formally does not work. A computer cannot run unless there is a program to express the rule completely but somehow human beings can manage without it. There were researchers who studied situational theory at Stanford University, and I thought they were studying something similar but it was different. What I learned from reading Dr. Atsunobu Ichikawa's *Boso Suru Kagaku Gijutsu Bunmei* (Runaway Science and Technology Civilization) was that Stanford researchers look down at situations from above. This means that they assume there is a being like god or the constitution that transcends the system in question, while Japan allows different rules for different groups. We want a situated representation, or a view from inside the system. I think that is the difference.

The experiment introduced by linguist Dr. Yoshihiko Ikegami is illuminating. The first sentence of Yasunari Kawabata's *Snow Country* translates into English as "The train came out of the long tunnel into the snow country." When a reader of the English version draws a picture, it is drawn as the train exiting a tunnel from the bird's eye perspective, while a reader of the original Japanese version draws a picture from the passenger's point of view, from inside the train. Anyway, the position of synthesis includes the analysis as its part. I am thinking recently that synthesis is not the counterpart of science, but contains science within. Something larger is constructed only after proper science. In fact, when we excersize science, we run the loop of hypothesis and verification. The hypothesis is made, experiment is done, and if the hypothesis is rejected, we revise it.

Another point is about dealing with multilayered

**Dr. Ken'ichi Takano**

**Dr. Hideyuki Nakashima**

systems. There is the loop of noesis and noema, which are terminologies first used by Husserl and then used by phenomenologist Bin Kimura. Taking music as an example, the “future noema” is a score of the music that one wishes to play, “noesis” is the sound actually played, and “current noema” is the music conceived by hearing the sounds played. Assume that there is an idea or a requirement, and say that it is externalized and an object is created, but when the object is analyzed, there is a slight gap between the object and the initial idea. Therefore, it goes back to the requirement again. There are cases where the design is adjusted, but there are also cases where the initial requirement is found to be wrong and reconsidered. However, I think the interaction with the environment that is not present in the initial assumption plays a large role. When we talk about service science, I would say that this interaction with the environment corresponds to the actual execution of service. Hence, design is what is done at the level of conceptual layer, or noema, and service is what is actually done at the physical layer, or noesis, and I think we must run back and forth from one to the other.

### Maeno

Although the manner of expression is different, I agree. I think we are doing the same thing.

### Nishimura

I think musical performance is an extremely good example. It means that what was imagined in the mind, or what one only thought about is actually put into action. The actual action may go in a completely different direction than imagined, or it’s called controllability in control engineering, but one may realize that the input in full force is meaningless. Then one must approach from a different direction. There is relatively a large number of people who end up with an armchair theory only, but one will understand if some of the theory is put into action. I think it is like turning the loop in a short time.

### Maeno

Exactly as you say. The old system engineering said, “It is entirely possible if it is planned. There is supposed to be no noesis.” However, current systems engineering is about repeating or taking in the design thinking. We include in the education the way of problem solving by subjectivity or immersion of oneself rather than taking the god’s point of view.

### Takano

In relation, I think the perspective of QCD (quality, cost, and delivery) is extremely important. To complete the project successfully, the upstream process in the project implementation is important. One must think about the concept of operations, consider the use cases of the product at the beginning, ponder what kind of usages there are and which demands will arise, and then think through on behalf of the stakeholders. If this is done, there is the merit of being able to develop, at the initial stage, only the functions that are frequently used. We engage in such verification research.

### Nishimura

I think it is important to think as much as possible of the environment around the system as well as the interaction with the external systems.

## Analysis of synthesis method for linking the research result to society

### Kobayashi

The requirements of *Synthesiology* are “to describe the research goal” “to describe the social value of the research goal,” “to present the scenario and to select the elements,” and “to correlate the elements and to integrate and synthesize them.” To study what types of synthesis methods were used, in 2012, we analyzed 70 papers published in *Synthesiology*. Through this study, I considered three basic forms of synthesis method: 1) aufheben type that is a method of creating new technology by integrating very different elemental technologies A and B, 2) breakthrough type that is a method of combining the realized important elemental technology with peripheral technology to nurture them into an integrated technology, and 3) strategic selection type in which the synthesis is done by strategically selecting the elemental technologies. We conducted the analysis based on these three types, but realized that feedback was also important. The feedback loop must be turned several times, particularly in biotechnology, life science, and human technology that require verification through test runs in the real society. Also, the method for introducing the technology into society did not readily emerge from these papers. Dr. Akamatsu, would you explain the situation?

### Akamatsu

Our target is mostly natural science and technology, but if we create a product, it is meaningless unless it is used in society. Considering how the products are introduced to society, I categorized the ways in which the authors of the papers accomplished this.

Roughly categorizing the cases where “the demand is clear

**Dr. Motoyuki Akamatsu**

in industry," "the demand is not clear in industry," and "it is established and diffused as an industry," the ones with "clear demands" include, for example, the construction of a traceability system for the metrology standard. In the world of standards for precision verification, the goal is clear, and although there may be more than one answer, it is a world that allows a logical scenario of what is necessary, what systems are necessary in order to supply the standard, and where it is supplied. However in the case where "the demand is not clear in industry," there is no logic that fills the holes because you do not know where the holes are. By exhibiting the elemental technology and providing samples, we get the potential target users to actually use the prototypes, and have them extract the issues. This is fairly simple, but there is a great hurdle in getting the people of the companies to use the research results in reality. In general, people are all conservative, and although they know the merits of introducing a new technology, they cannot take the step. What do we do? In this case, we build a strong relationship with the corporate people to promote the understanding of the product value, and wait until they feel, "We got to do this." In the case of "establishment and expansion as industry," we see examples among papers of a product being introduced to the perceptual lead user who is one step ahead of the trend and everyone else follows. Another example is a product spreading through collaboration and joint development with competitors on a common issue of standardization as seen in the diffusion of car navigation. The researchers choose the method that they feel is the best, and I think it will be good if we can see beforehand what method should be taken for certain types of products.

## Issues of system design and management science and synthesiology toward innovation

### Kobayashi

My expectation is by deepening the study of such patterns, we might be able to find out what elements are needed or how things can be combined to achieve innovation. Is it possible in SDM studies to say, "Innovation happens if we do this and that"?

### Nakashima

If we know that, it's not innovation!

Dr. Naoto Kobayashi

### Nishimura

I really think so. Recently, there's the system of systems, and even if a product or service is introduced thinking that one understands the requirement, it turns out that rather than following the requirement, it is used completely differently due to the interaction with other systems. The person who devised the current email system probably thought it would be a great idea to be able to send a simple message like, "Hey, let's go have lunch together," but now it's become a system where we're not sure whether it's useful or not useful for work. Whether it was made according to requirement, perhaps it was not, we don't know, but it's somehow generating innovation. We try to intentionally design an innovation, but it's quite difficult.

### Maeno

There are methods that are widely diffused in society, and although we can't make Steve Jobs just by using them, I think an ordinary person can become slightly more creative and innovative. I think our education is one such method where design thinking and systems engineering are combined.

### Nishimura

Explaining from the systems engineering aspect, if, for example, there is a product and we define its category by saying, "This can be used only for a certain requirement," it ends there. We must take one step back, and derive some function from the requirement. Considering what should be done in achieving the function, perhaps something different may work better than a certain physical object. In that case, a different thing leads to innovation for this particular function, and this can be considered as relatively simple systems engineering.

### Nakashima

When we teach software to students, I say exactly that. Creating a system procicely following the requirement is not enough. In IT, there is a term called "demand development" where we must think what it is that is really wanted.

### Maeno

We are thinking in the same way. Continuing what I was saying, the system is broken down into physical, function, and purpose in systems engineering. Structuralization of the problem is the first thing to do in systems engineering, and it is done by backtracking to the function. In design thinking, the objective itself is structuralized by methods such as building a value ladder. When you track back to "what is the origin?" you may arrive ultimately to peace and happiness. You write them out, and when you change the structure in the highly abstract level, it becomes very innovative. When innovation is seen from systems engineering, it is exactly the design change at the highly abstract level. Innovation that seems way off the wall for an ordinary person may merely be a design improvement when we analyze the objective. I think we can understand it in this manner.

### Nishimura

When I think of innovation, I actually think it is a matter of the mind such as breaking the framework or transcending the boundary. Of objectives, people don't really question about whether an objective is truly the objective. When a professor says, "This is the objective," the students may write a paper without questioning the statement.

### Takano

There is a major problem of psychological confinement, and I think the biggest problem is how to breakthrough this, and also that students can only think of a society that he/she can imagine. I think the engine to overcome this confinement may be to engage in meta-thinking for creative development, and to think about the "why this" and "why that."

### Akamatsu

Aside from whether using the word "innovation" is appropriate, in the case of technology, it's whether people will use the product. If the product does not diffuse in society, at least, it won't be called an innovation. Is there an example of a system that was actually tried on site and was autonomously accepted and used, even after the student completed the thesis research and left SDM?

### Maeno

Since the majority of our students are working people, there are several cases where the student is a company president, writes the thesis, and actually uses the system at the company. There are many students who are becoming entrepreneurs rather than seeking employment at large companies. There are cases where the themes of the thesis are realized in a corporate setting. So, there are many cases where the results of the thesis lead to actual business. Time is required for the verification of a large-scale system, and in some cases about 10 years are required. In contrast, when a small system is started by one student, there are more than a few cases where business has actually taken off.

### Akamatsu

Were they successful because they grasped the social demands accurately?

### Maeno

Yes. Moreover, our discipline includes management, and I think one of the major reasons is because appropriate management was done. In the future, we would like to strengthen the management part, and to change into an organization that can achieve innovative development at the same time.

### Kobayashi

I think it is great that SDM incorporated management. Are you trying to make a discipline that includes the method of implementation?

### Kohtake

The whole lifecycle, from implementation, operation, to disposal, all the way to the end is the subject of the discipline.

### Maeno

We have a course called project management in systems engineering, and there, we provide education for managing a large-scale project. Also, there is a course on organization management led by Prof. Takano.

### Takano

Currently, we are working on the diagnosis of the organization, and the goals are "productivity" and "safety." Productivity and safety are considered performance, and currently we are doing a large-scale survey where we may be able to explain the level of performance in terms of the culture and climate of an organization. We are getting results that if the corporate culture is changed for the better, the safety performance increases and the business performance rises. We are gaining understanding of the top management of companies, and we are actually conducting diagnosis of the safety culture in many companies. In such cases, we can mutually agree, "This is the problem in your organization," but when we enter into the domain of how to specifically change the organization, it's not easy because it involves people, money, and resource. However, we are getting examples of a couple of companies that succeeded in making improvements autonomously. For productivity, or improvement of business performance, we are like physicians that point out only the bad part, but I hope it leads to autonomous change of the organization in the future.

### Akamatsu

Is such system design management for people who already have their own specialty or discipline, or can the people who do not have any specialty, like the students fresh out of college, learn anything if they are taught?

### Nishimura

I think the fresh graduates may be at a disadvantage because they have no experience working and may not understand immediately what we are talking about. Those with work experience have a solid framework, so when they are asked something, they can reply, "Are you talking about this?" However, at the same time, a fresh graduate may say something totally off the wall, and that may be quite interesting.

### Maeno

Another thing is, it is not just the experienced person teaching the fresh graduates, but there's "learning in teaching." Because there are many people with diverse specialties, there is an atmosphere where everyone teaches everyone else. We learn a lot, too. We must instruct the fresh graduates carefully. In engaging in teamwork, the elders may actually grow by being with inexperienced youths.

### Kohtake

The students with work experience are likely to gain insight during the two years they stay with us. On the other hand, the fresh graduates may start up a virtual company in one of the courses, and actually design a service that is actually operable using small robots. They think they know it all, but they don't. But when they join a company, they realize in the real world, "This is what the professor was saying in the class a year ago." They come back to us and say, "Now I understand how I received the education of seeing the forest for the trees." When they have such experience, it becomes clear to them what they must pursue deeply to continue learning, and I'm glad to hear that.

### Kobayashi

We want to make *Synthesiology* a much more open journal. I would like to hear if you have any expectations for *Synthesiology* in the future.

### Maeno

When I first found *Synthesiology*, I was surprised. I thought we were blazing a trail, but found that *Synthesiology* was heading for the same destination. Although our stances were different, I was very happy to find that the seekers of same goal were present in a Japanese national research institute and a private university. We are confident that the SDM studies has spread in the past five years and is gaining awareness, and we wish to collaborate with you further in the future.

### Kobayashi

Thank you very much for joining us today.

This roundtable talk was held at the Graduate School of System Design Management, Keio University at Yokohama on July 25, 2013.

**Dr. Naohiko Kohtake**

## Profile

**Naohiko KOHTAKE**
After completing the courses at the Keio University Graduate School, joined the National Space Development Agency (NASDA) of Japan. Worked on the R&D and launching of rockets. Researcher at the European Space Agency (ESA), and senior developer at the Japan Aerospace Exploration Agency (JAXA). Lead the independent verification and confirmation of efficacy of the software used in the International Space Station and satellites. Also engaged in international collaboration with NASA and ESA. Associate Professor, Keio University from FY 2009. Member of Sentinel Asia Project, member of the steering committee for Multi-GNSS Asia, and representative of IMES Consortium. Doctor (Policy & Media).

**Ken'ichi TAKANO**
Completed the master's course at the Graduate School of Engineering, Nagoya University in 1980. Joined the Central Research Institute of Electric Power Industry (CRIEPI) in 1980. Visiting Fellow, University of Manchester in 1995; part-time lecturer, Waseda University; Senior Researcher, CRIEPI; and current position in 2007. Doctor (Engineering). Worked on risk management and human factor in large-scale technology systems. Books include: *Soshiki Jiko* (Organizational Accident) (JUSE Press), *Hoshu Jiko* (Maintenance Accidents) (JUSE Press), and others. Specialties are development of organizational diagnosis and root cause analysis methods as well as practice for emergence of the safety culture. Experience in practice and consultation of safety management.

**Hideyuki NAKASHIMA**
Doctor of Engineering from the Graduate School of Information Science and Technology, The University of Tokyo in 1983. Joined the Electrotechnical Laboratory in 1983. Director of Cyber Assist Research Center, AIST in 2001; and President of Future University Hakodate in 2004. Former Chairman, Japanese Cognitive Science Society; Former Vice Chairman, Information Processing Society of Japan; currently Editor-in-Chief, Information Processing Society of Japan. Books include: *Handbook of Ambient Intelligence and Smart Environments* (Springer), *Chino No Nazo* (Mystery of Intelligence) (Kodansha), *AI Jiten* (AI Encyclopedia) (Kyoritsu Shuppan), *Shiko* (Thought) (Cognitive Science Series #8, Iwanami Shoten), and *Prolog* (Sangyo Tosho).

**Hidekazu NISHIMURA**
Completed the doctor's course in Mechanical Engineering, Graduate School of Science and Technology, Keio University in March 1990 (Ph.D.). Assistant Professor, Faculty of Engineering, Chiba University in April 1990; and Associate Professor in 1995. Currently, Professor, Keio University from April 2007. Professor, Graduate School of System Design and Management, Keio University from April 2008. Engages in education and research for model-based systems engineering. Books include: *The System Modeling Language SysML* (translation supervisor for *A Practical Guide to SysML*), *Basics of Control Theory by MATLAB: Control System Design by MATLAB* (joint author), and others. Fellow of The Japan Society of Mechanical Engineers; Vice Chairman and Director of General Affairs for FY 2013, The Society of Instrument and Control Engineers; as well as members of

IEEE, INCOSE, and others.

**Takashi MAENO**
Graduated from the Tokyo Institute of Technology in 1984, and completed the master's course at the Tokyo Institute of Technology in 1986. Worked at Canon Inc., visiting researcher at University of California at Berkley, and visiting professor at Harvard University. Currently, Professor and Chairman of the Graduate School of System Design and Management, Keio University. Doctor (Engineering). Books include: *No Ha Naze "Kokoro" Wo Tsukuttanoka* (Why Did the Brain Create Heart?) (Chikuma Shobo, 2004), *Shiko Noryoku No Tsukuri-kata* (How to Make Thinking Brain Power) (Kadokawa Shoten, 2010), and others. Specialties are human-machine interface design, system design management, regional vitalization, innovation education, etc.