Cross-ministerial Strategic Innovation Promotion Program (SIP)

Research and Development Plan for Big-Data and AI-Enabled Cyberspace Technologies

July 25, 2019

Director General for Science, Technology and Innovation Policy,

Cabinet Office

Contents

Overview of Research and Development Plan

1. Significance and Goals

The society envisioned as part of Society 5.0 is expected to spur the creation of a highly integrated cyberspace and physical space. Innovations born from the use of big data and AI may create new services and business models, create new values in various fields, and bring about a paradigm shift in economic and social systems. It is essential to create a system in which cyberspace and physical space are interconnected to realize Society 5.0. However, there are still various development-related factors and issues that need to be resolved.

This project will particularly establish highly-sophisticated "human interaction platform technology," "cross-domain data exchange platform technology," and "AI-based automatic negotiation platform technology," the subcategories of "cyberspace platform technology," which contribute to human-AI collaboration and will conduct social implementation of cyber-physical systems utilizing big data and AI.

More specifically, under "human interaction platform technology", the goal is to innovate the areas that require highly-sophisticated interactions, such as nursing care, education, and customer service. The use of AI to analyze the on-site information collected from changes in personal situations, conversations, facial expressions, gestures, and so on, which has not been analyzed before, will allow us to understand personal cognitive functions and behavior that are complicated and difficult to predict and will support not only prescribed scenario-based interactions but also quick, flexible, and logical decision-making and communication in given situations. Such a new intellectual social infrastructure will be established which will promote Society 5.0 by means of developing and dispersing highly sophisticated technologies.

Under "cross-domain data exchange platform technology", the goal is to connect data held separately by industry, government, and academia and to supply them as big data that can be utilized by AI. An ecosystem that enables sustainable and independent operation will be developed by means of developing cross-domain data sharing and utilization technologies/platforms.

Moreover, under "AI-based automatic negotiation platform technology", the goal is to develop an AI-based automatic negotiation platform technology which automatically adjust win-win conditions through multiple AI collaborations. The world which control AI more effectively and generate new win-win opportunities will be developed in which multiple AIs will cooperate and collaborate in various systems controlled by different AI platforms.

2. Content of the Research

In order to conduct the social implementation of cyber-physical systems which realizes Society 5.0 with highly integrated cyberspace and physical space, in this research, human interaction platform technology, cross-domain data exchange platform technology, and AI-based automatic negotiation platform technology that support/enhance human cognition capabilities through human-AI collaboration will be developed as big data and AI-enabled platform technologies.

The developed platform will attempt to accelerate the creation of new business models that utilize big data and AI by conducting data collection; prototyping; technology verification/evaluation at multiple sites in areas in which Japan has high-quality, physical space information and in areas that have social issues to be resolved by the Japanese government; verification of the effectiveness of these platform technologies; and creation of multiple practical applications. In this process, the three key areas indicated in the Industrialization Roadmap in Artificial Intelligence Technology Strategy—productivity; health, medical, and long-term care; and mobility—are taken into account.

Specifically, the following research and development activities will be conducted.

(1) Human interaction platform technology

(1-1) Cognitive interaction support technology: Advanced interaction support technology that collects and structures non-verbal data related to human cognition and behavior to realize advanced human-AI collaboration, and supports situational decision-making and communication with others based on individual needs.

(1-2) Advanced multimodal dialogue technology: Advanced dialogue processing technology that enables multimodal memorization, integration, cognition, and judgment for human-AI collaboration.

(1-3) Learning support technology: Technology that optimizes education and learning activities by collecting big data related to teachers and students from educational sites and combining them with AI.

(1-4) Nursing care support technology: Technology that reduces the burden on both caregivers and care recipients by collecting big data related to them from nursing care sites and combining them with AI.

(2) Cross-domain data exchange platform technology: Technology for cross-domain data sharing/utilization and development of a one-stop platform for providing these data.

(3) AI-based automatic negotiation platform technology: Technology for automatic

negotiation and collaboration between multiple AI platforms.

(4) Architecture development: Development of an architecture that enables cross-domain and cross-company collaboration.

3. Implementation Structure

Yuichiro Anzai, the Program Director (PD), is responsible for formulating and promoting research and development plans. The Promotion Committee, chaired by the PD, is composed of relevant ministries and agencies, specialists, and intellectuals, and the Cabinet Office serves as secretariat and performs general coordination. Research and development will be promoted by research managers, who will be selected through public offering, through utilization of the New Energy and Industrial Technology Development Organization (NEDO), an organization responsible for supervising the project. The progress of each research theme will be controlled under the management of NEDO. Masaaki Mochimaru, Noboru Koshizuka, and Takashi Washio are appointed as sub-PDs for the human interaction platform technology, cross-domain data exchange platform technology, and AI-based automatic negotiation platform technology projects, respectively, and Takayoshi Kawakami is appointed as the Strategy Coordinator (SC), responsible for overseeing exit strategies. The PD, sub-PDs, and SC will work together to implement the research and development, focusing on exit strategies.

4. Management of Intellectual Properties

The Intellectual Property Committee, responsible for the management of intellectual properties in this project, will be established in NEDO or an institution to which the selected research manager belongs (trustee) for the purpose of coordination, so that the trend of intellectual properties applied by the trustee may be understood and managed, and such properties may be more conveniently used for industrial purposes.

5. Evaluation

Prior to the evaluation made by the Governing Board at the end of each fiscal year, the research managers, PD, and management agencies will conduct self-inspection.

6. Exit Strategies

In areas where automation is not easy and collaboration between human and AI is considered effective (e.g., nursing care, education, and customer service fields), this SIP theme encourages participants to create new services and businesses by having end-users, including companies, participate from the initial stage of development, and having

developers and a wide spectrum of users conduct PoCs (proofs of concepts) using the platform technologies developed in this project.

The project will also collaborate with other related SIP projects, including "Intelligent Knowledge Processing Infrastructure Integrating Physical and Virtual Domains," "Cyber Physical Security for IoT Society," "Smart Logistics Service," and "Technologies for smart bio-industry and agriculture," and examine specific methods of social implementation. In particular, there will be close collaboration with the "Intelligent Knowledge Processing Infrastructure Integrating Physical and Virtual Domains" project to realize high-level integration between cyberspace and physical space.

1. Significance and Goals

(1) Background and Situations Inside and Outside of Japan

The society envisioned as part of Society 5.0, described in "The 5th Science and Technology Basic Plan," is expected to spur the creation of a highly merged cyberspace and physical space. Innovations born from the use of big data and artificial intelligence (AI) may create new services and business models, create new values in various domains, and bring about a paradigm shift in economic and social systems. It is essential to create a system in which cyberspace and physical space are interconnected to realize Society 5.0. However, there are still various development-related factors and issues that need to be resolved. In addition, there is a need to collect big data, not only for each domain as has been done in the past, but across different domains to drive innovation through AI technology, and use big data for the social implementation of AI technology in the physical space.

Outside of Japan, the utilization of big data and AI technology has been led in the past few years by U.S. IT companies that were successful in corralling and utilizing massive amounts of data on the Internet. While U.S. and Chinese companies are fighting fiercely to gain dominance, Japanese companies are lagging behind the U.S. and China in terms of number of research papers published and number of business applications implemented. With regard to the training of human resources for the development and utilization of AI, it is estimated that there will be a shortage of about 50,000 and 300,000 workers in the advanced IT and IT fields, respectively, in 2020.[1] There is an urgent need to train a large number of workers who understand practical AI technology, drastically improve Japan's industrial competitiveness, and accelerate the utilization of AI technology in societies. With respect to government-led initiatives related to data linkage, NIEM in the United States and SEMIC in Europe established data linkage frameworks in 2005 and 2011, respectively, by starting their initiatives on data linkage standards. In China, data are now strictly controlled after a law was enforced to regulate the export of personal data and other relevant data.

For Japan, the first country in the world to experience a seriously declining birthrate and aging population, to overcome the challenges posed by the decline in workforce and build an ecosystem that serves as a model for the world, the country needs to gather big data, including good-quality on-site data in Japan, merge it with AI technology, conduct social implementation ahead of other countries, strengthen Japan’s industrial

[1] "Findings of METI's Study of Recent Trends and Future Estimates Concerning IT Human Resource," Ministry of Economy, Trade and Industry (June 2016). The estimates of numbers of IT workers are for the medium-level scenario.

competitiveness while complementing the declining labor force, and improve productivity.

(2) Significance and Strategic Importance

In the Japanese government, the Artificial Intelligence Technology Strategy Council was established in April 2016, and this council has served as a command post to accelerate the consistent implementation of AI technology initiatives from their research and development stage to social implementation, in collaboration with other agencies. In March 2017, the "Artificial Intelligence Technology Strategy" was compiled with the industrialization roadmap, which focuses on the fields of productivity; health, medical, and long-term care; mobility; and information security. In December 2016, the Council for Science, Technology and Innovation and the Council on Economic and Fiscal Policy jointly compiled the "Public & Private Investment Expansion Initiatives for STI," and Public/Private R&D Investment Strategic Expansion Program (PRISM) was established based on this initiative. PRISM identified innovative cyberspace platform technology as the effective (target) area for drawing in research and development investments from the private sector and proposed the collaboration of initiatives between different government agencies and promotion of research and development oriented to the whole field. According to the "New Economic Policy Package" approved by the Cabinet in December 2017, "Productivity Revolution" and "Human Resources Development Revolution" go hand in hand in confronting the issues of declining birthrate and aging population to sustain economic growth. The Package also proposes conducting research and development under the SIP and PRISM initiatives for productivity revolution, steady promotion of social implementation, and creation of technology bases, as well as setting up a data linkage infrastructure within three years, which enables to exchange the cross-domain data dispersed in the central/local governments and the private sector, to create a new intellectual social infrastructure that is critical to realizing Society 5.0.

For this reason, this project will establish, in particular, highly sophisticated "human interaction platform technology," "cross-domain data exchange platform technology," and "AI-based automatic negotiation platform technology," the subcategories of "cyberspace platform technology," which help human-AI collaboration, and conduct the social implementation of cyber-physical systems that utilize big data and AI.

More specifically, under "human interaction platform technology", the goal is to innovate the areas that require highly-sophisticated interactions, such as nursing care, education, and customer service. The use of AI to analyze the on-site information collected from changes in personal situations, conversations, facial expressions, gestures, and so on, which has not been analyzed before, will allow us to understand personal cognitive

functions and behavior that are complicated and difficult to predict and will support not only prescribed scenario-based interactions but also quick, flexible, and logical decision-making and communication in given situations. Such a new and intelligent social platform will be established which will promote Society 5.0 by means of developing and dispersing highly sophisticated technologies.

Under "cross-domain data exchange platform technology", the goal is to connect data held separately by industry, government, and academia and to supply them as big data that can be utilized by AI. An ecosystem that enables sustainable and independent operation will be developed by means of developing cross-domain data sharing and utilization technologies/platforms.

Moreover, under "AI-based automatic negotiation platform technology", the goal is to develop an AI-based automatic negotiation platform technology which automatically adjust win-win conditions through multiple AI collaborations. The world which control AI more effectively and generate new win-win opportunities will be developed in which multiple AIs will cooperate and collaborate in various systems controlled by different AI platforms.

This project will, as a core project of PRISM's "Innovative Cyberspace Platform Technology" focused on promoting public and private sector investments, aim for the practical use of technologies in five years. Establishing big data and AI-based technologies and conducting social implementation is highly significant, as it is difficult for companies to take risks on their own.

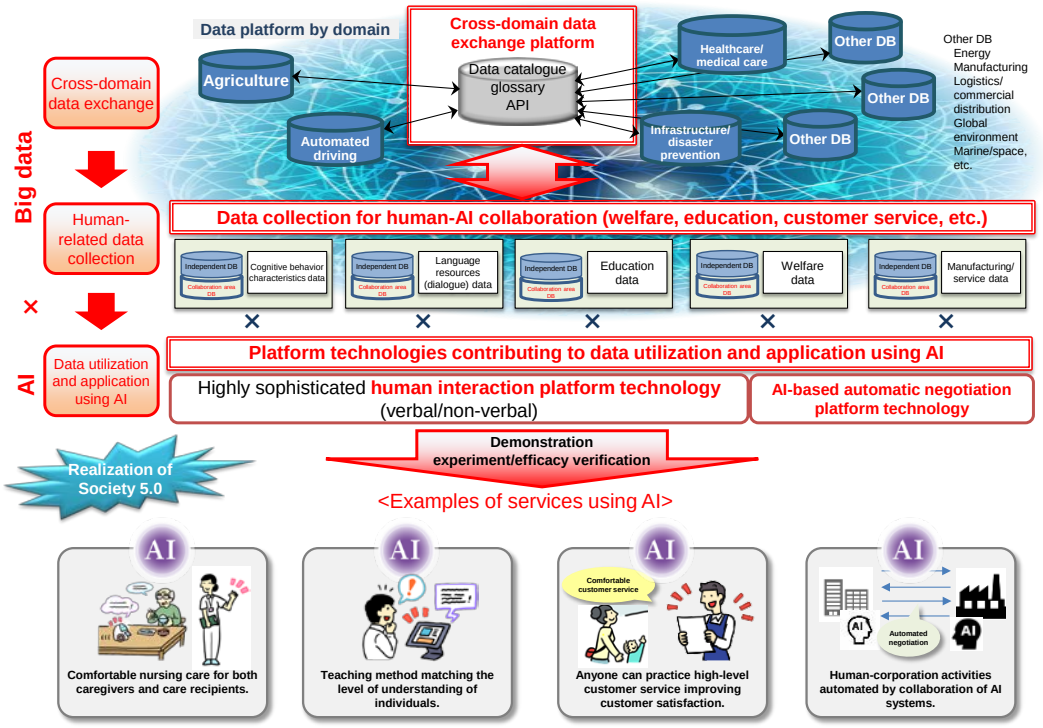

Figure 1-1. Overall Concept of Big-Data and AI-Enabled Cyberspace Technologies

(3) Objective/Aim

(i) Toward Realization of Society 5.0

- To establish the cyberspace platform technologies described below, carry out social implementation of cyber-physical systems utilizing big data and AI, and create 20 or more use cases of practical applications that improve productivity (e.g., work time, learning speed, and error rate)[2] by at least 10% to realize Society 5.0, where there is human-AI collaboration.

  - ➢ To develop human interaction technology that enables advanced human-AI collaboration. To verify the effectiveness of this technology through PoCs (proofs of concepts) and to create the use cases of practical applications in areas where automation is difficult and human-AI collaboration is considered effective (e.g., nursing care, education, and customer service fields).
  - ➢ To create the use cases of practical applications by developing a cross-domain data exchange platform within three years, which links data held separately by businesses, governments, and academic organizations and provides big data to be utilized by AI. The platform is to be put into operation within five years.

[2] Calculated and compared based on factors such as work time, learning speed, comprehension level, error rate, safety rate, or energy saving.

- To develop an AI-based automatic negotiation platform technology, which enables AI to inter-link with other AI platforms and automatically adjust conditions to create win-win situations. To verify the effectiveness of this technology, and to create use cases of practical applications through PoCs.

(ii) Social Objectives

- The utilization of big data and AI leads to the conception of new business models and creation of new services and values in various fields. It thereby contributes to both the improvement of productivity and resolution of social issues.
  - To improve productivity (e.g., work time, learning speed, and error rate) by at least 10% through workload reduction and automation in the service industry (e.g., nursing care, education, and customer service fields), where machine automation is difficult and human intervention is required. (This would contribute to a 2 percent annual improvement in productivity (in real GDP per capita, per hour)[3] in Japan.)
  - To improve the issue of caregiver shortage through workload reduction and automation of caregivers' work. (Easing the shortage of caregivers, which is expected to rise to approximately 370,000 in 2025[4] and improving the caregiver turnover rate, which was about 17% in 2015.[5])
  - To reduce social security costs through promotion of dementia prevention. (Lowering long-term care costs, which are expected to reach approximately 20 trillion yen in 2025.[6])
  - To increase the opportunities of winning contracts for small and medium-sized manufacturing companies through discovery/coordination of opportunities, using automatic inter-AI collaborative technologies.
- Among the above objectives, to drive learning innovation that enables customized learning, merging of humanities and sciences, and internationalization through research and development related to learning support uses big data and AI, and to train the following types of personnel suitable for the AI era.

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[3] According to the "New Economic Policy Package" approved by the Cabinet on December 8, 2017, the aim is to double the productivity in Japan from the 0.9% average growth rate recorded in five years until 2015 and increase the productivity by 2% annually.

[4] "Estimation of Supply and Demand for Care Workers for 2025," Ministry of Health, Labor and Welfare (June 2015)

[5] "2016 Care Worker Survey," Care Work Foundation (August 2017)

[6] Material from Caregiver Fee Subcommittee and Welfare Division of the Social Security Council, the Ministry of Health, Labor and Welfare (April 2014)

- Personnel who can develop and practice innovative business models based on advanced information technology such as AI technology, and innovative models for various economic and social fields, including production, logistics, services, and administrative government fields. (Advanced IT workers and IT workers are estimated to be short by approximately 50,000 and 300,000, respectively, in 2020.[7])
- World-class AI workers with not only technical skills but also problem-finding, problem-structuring, international communication, and practical skills.

(iii) Industrial Objectives

- To develop among the first in the world a data linkage platform that enables to exchange cross-domain data. To create new values/services and business models by using AI technologies in the domains in which Japan has high-quality, physical space information and in Japan's competitive industries (e.g., robot industry), and to contribute to bolstering industrial competitiveness.
- To encourage the creation of new businesses that will lead the world by supporting the development and practice of innovative models for various economic and social fields, including the fields of production, logistics, services, and administrative government.
- To create a new industrial field, which uses next-generation AI technology supporting non-verbal communication, such as changes in situations, facial expressions, and body movements.
- To enable Japan to take the lead in the next generation industry and beyond through a platform for designing and evaluating multi-sensory, multi-dimensional contents that combine not only audiovisual but also tactile sensations.
- To encourage innovations in a wide range of industrial fields through disclosure of the results of research and development on the advanced multimodal dialogue platform technology.
  - Example: Strengthening the international competitiveness of the service robot industry. (The market expectation for Japan's robot industry is approximately 9.7 trillion yen in 2025[8]. (The service robot market will surpass the industrial robot market in 2025.))

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[7] "Findings of METI's Study of Recent Trends and Future Estimates Concerning IT Human Resource," Ministry of Economy, Trade and Industry (June 2016). The estimates of numbers of IT workers are for the medium-level scenario.

[8] "Market Research on Future of Robotics Industry," NEDO (April 2010)

- Example: Making the elderly support work the world-leading industry by using AI with accumulated know-how on nursing care. (The 2035 demand forecast for robots in nursing care, welfare, health care, and smart home fields is approximately 1.29 trillion yen[8] (5.1 times the amount in 2015).)

(iv) Technical Objectives

- To develop a one-stop platform to allow users to use a data catalog (metadata) to search where the data held by businesses, governments, and academic organizations reside and obtain data in various fields via API. To ensure the interoperability of data across different domains by collaborating with relevant ministries that manage cross-domain core vocabularies, domain-specific vocabularies, and data structures.
- To encode, construct, and analyze a vast amount of non-verbalized information, including facial expressions, tactile sensations, postures, mannerisms, and situational changes in daily life and work, as with verbalized information, and to improve situational decision-making and provision of communication support.
- To enable flexible and advanced multimodal dialogues as well as prescribed scenario-based conversations through any knowledge and information available in the world.
- To create a framework that enables multiple AI platforms to link functionally, in accordance with social systems.

(v) Objectives Pertaining to Institutional Systems

- To promote the international standardization of safety guidelines for next-generation information support and to boost the competitiveness of Japanese industries.
- To promote reforms in relevant institutional systems while studying through PoCs issues regarding information-related legislation (e.g., protection of personal information, copyright protection, and systems specific to application fields) on technology development and social implementation and introduction of technologies.

(vi) Global Benchmarks

- Over the past few years, the utilization of AI technology has been led by U.S. IT companies that have been successful in corralling and utilizing massive amounts of data on the Internet. While U.S. and Chinese companies are fighting fiercely to gain dominance, Japanese companies are lagging behind the U.S. and China in terms of the number of business applications implemented. Japan has been developing intra-domain data exchange platforms for some domains through SIP and other programs. However, these platforms are not yet completed, and collaborations related to the data

exchange between relevant organizations are not sufficient. Therefore, it is necessary to swiftly consider how to handle the cyber security, protection of personal information, and other issues and develop a cross-domain data exchange platform, while ensuring interoperability with Europe and the United States.

- Current AI technology is software that learns from a large amount of data (big data) with machine learning and deep learning, and acquires necessary functions without human intervention. It is dependent on the amount of data available and mostly utilized on networks (cyberspace) that have a sufficient amount of data. There are many issues regarding the utilization of AI technology, in terms of utilization of AI technology in the physical space (as opposed to the Internet), particularly collaboration with people, and also from the perspective of reliability and safety. This is why there are only a few social implementation of AI. In recent years, many countries around the world actively studied the "human interaction" necessary in human-AI collaboration. The United States government defined seven strategic research goals for AI (e.g., high-risk research that can lead to high-reward payoffs over 5 years, 10 years, or more and development of effective methods for human-AI collaboration) in "The National Artificial Intelligence Research and Development Strategic Plan" (Office of the President of the United States, October 2016), and is taking on initiatives by focusing the allocation of federal budget in areas where private sector is less likely to invest. With respect to speech recognition, platform technologies that use cognitive characteristics data of linguistic information as its core are being established mainly by European and U.S. companies. Many applications of these technologies, however, are limited to patterned linguistic information. It is necessary to use data that are closer to the workplace and have safe and reliable technology in places where people and AI collaborate to improve productivity through human-AI collaboration. To make this possible, multimodal interaction technology developed through recognition of people-related verbal and non-verbal information and creation of a database of responses and actions for this information is essential.

(vii) Collaboration with Local Government Bodies

- To serve as a bridge between advanced technology and social challenges faced by workplaces, by having local governments participate in research and development and PoC activities and opening up the development results to local

governments, companies, universities, and research institutes from the research and development phase, based on appropriate open/close strategies.

2. Details of Research and Development (R&D)

To realize the social implementation of a cyber-physical system that highly integrates the cyberspace and physical spaces, which embodies Society 5.0, human interaction platform technology, cross-domain data exchange platform technology, and AI-based automatic negotiation platform technology that support/enhance human cognition capabilities through human-AI collaboration will be developed as platform technologies related to big data and AI. These three platform technologies will be addressed in this SIP activity to enable human-AI collaboration along with data distribution and AI system linkage and create a world where AI is used in every life scenario to support humans. Specifically, data related to advanced skills constructed in the human interaction domain will be integrated with the cross-domain data exchange platform and AI-based automatic negotiation platform to promote social implementation through data trading and AI system collaboration.

The overall objective of this project is to create more than 20 practical applications that improve productivity (work time, learning speed, and error rate, etc.) by more than 10%.

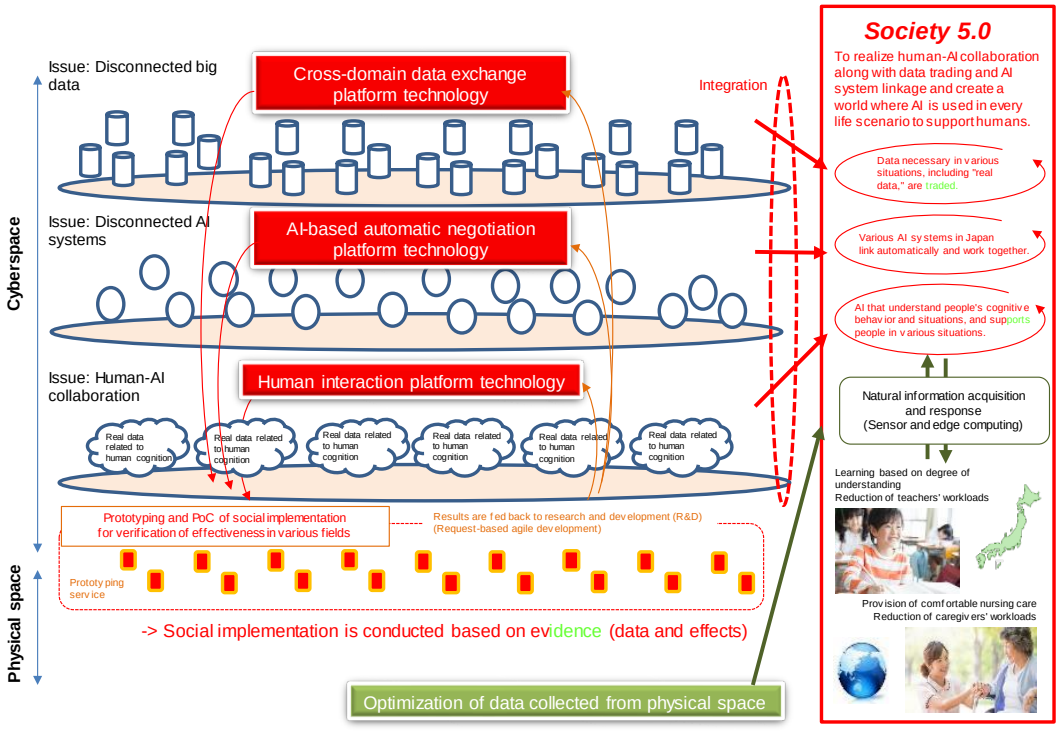

Figure 2-1. Overview of this Research and Development Activity

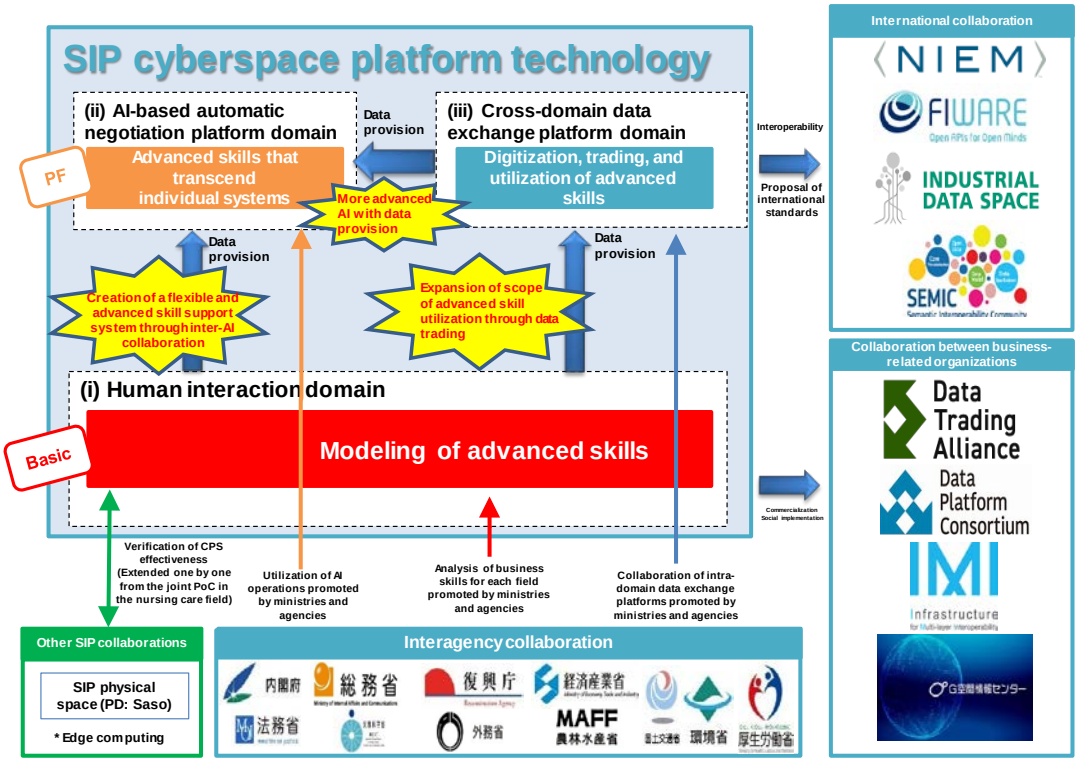

Figure 2-2. Synergy of the Three Platform Technologies

This project will conduct data collection, prototyping and technical verification/evaluation at multiple sites in areas with high-quality real-space information or with expected social issues in Japan, while taking into account the three key areas indicated in the Industrialization Roadmap in Artificial Intelligence Technology Strategy, namely, productivity; healthcare, medical care and long-term care; and mobility.

Specifically, research and development will be conducted in the following areas:

(1) Human interaction platform technology

(1-1) Cognitive interaction support technology: Development of advanced interaction support technology that collects and structures non-verbal data related to human behavior and cognition to realize advanced human-AI collaboration and supports making decisions in given situations and communicating with others based on individual needs.

(1-2) Advanced multimodal dialogue technology: Development of advanced dialogue processing technology that enables multimodal memory, integration, recognition, and judgment for human-AI collaboration.

(1-3) Learning support technology: Development of technology that optimizes education and learning activities by collecting big data from teachers and students at educational sites and using AI with them.

(1-4) Nursing care support technology: Technology that reduces the burden on both caregivers and care recipients by collecting big data from them at nursing care sites and using AI with them.

(2) Cross-domain data exchange platform technology: Development of technology for cross-domain data sharing and data utilization and one-stop platform for supplying these data.

(3) AI-based automatic negotiation platform technology: Development of technology for automatic negotiation and collaboration among multiple AIs.

(4) Architecture development: Development of an architecture that enables cross-domain and cross-company collaboration in domains such as smart cities.

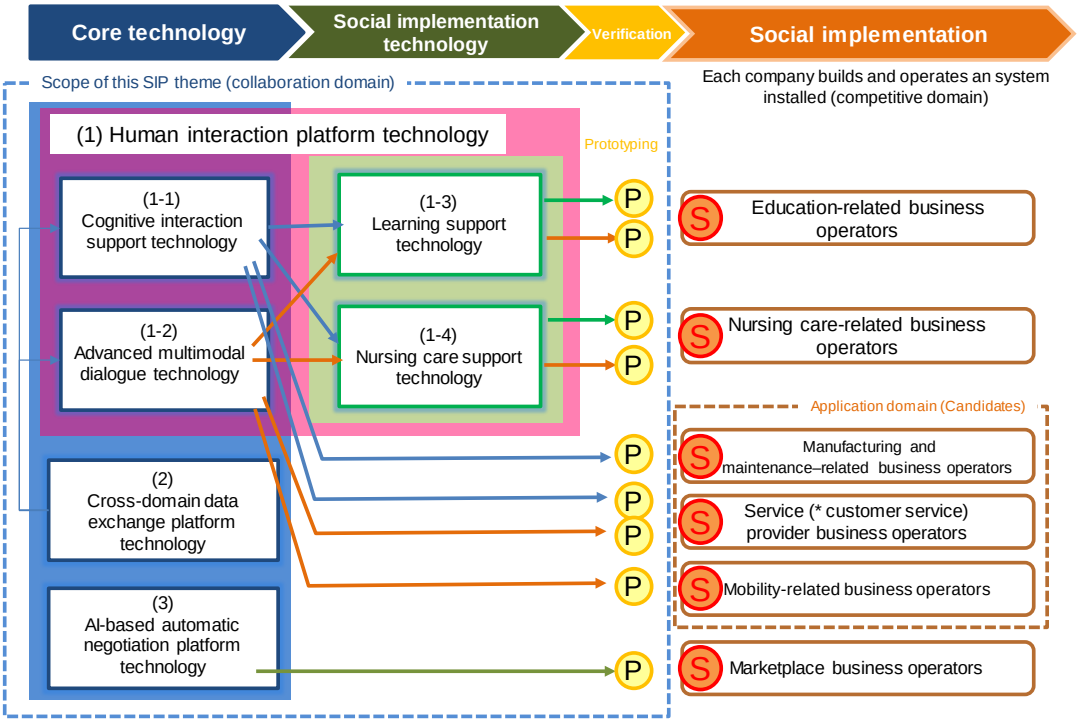

Figure 2-3. Overview of Research and Development Plan

(1) Human Interaction Platform Technology

Responsible Sub PD: Masaaki Mochimaru

This platform technology development aims the social implementation of AI, expansion, and training systems of highly skilled personnel that contribute to the improvement of productivity in Japan, and of the training services that utilize these systems. To achieve it, it is necessary for highly skilled personnel to identify and collect environment, action, and dialogue data potentially used to infer clients' internal cognition based on given situations and past experiences and to perform AI conversion, rather than simply to collect existing data and performing AI analysis. It is also essential to develop a

technology that integrates that AI with robots, remote VR, and teaching AR, and feeds data back through an integrated audio-visual-tactile interface. For social implementation, it is necessary to obtain PoC (proof of concept) evidence necessary for business deployment and international standardization as well as to solve these technical issues. Based on the evidence, dissemination will be done to the domestic B2B (customer service, manufacturing), B2G (learning, nursing care), and B2G2P (maintenance and management) areas.

For the social implementation of human interaction platform technology, a consortium (meta-consortium) will be formed for the social implementation of the results for this human interaction domain in the SIP. Also, an open innovation platform for the service industry will be constructed by encouraging participation of companies which will develop business using advanced personnel development systems, learning support systems, and nursing care support systems, which will use the systems, and which will implement improvements and field adaptation for the future.

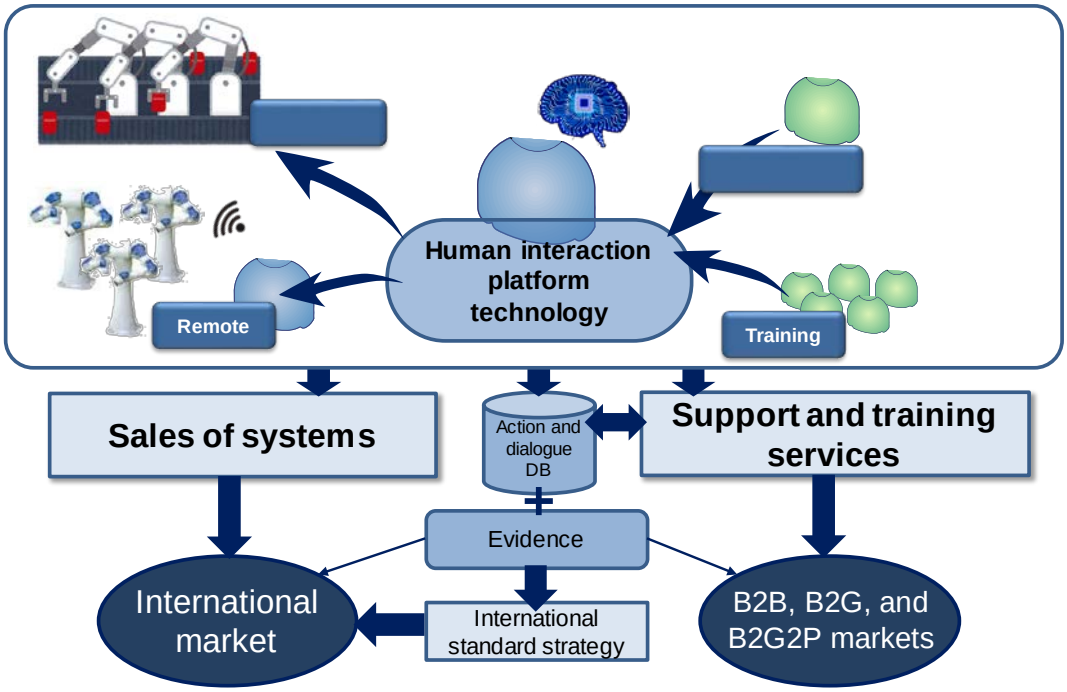

Figure 2-4. Exit Strategy for Human Interaction Platform Technology

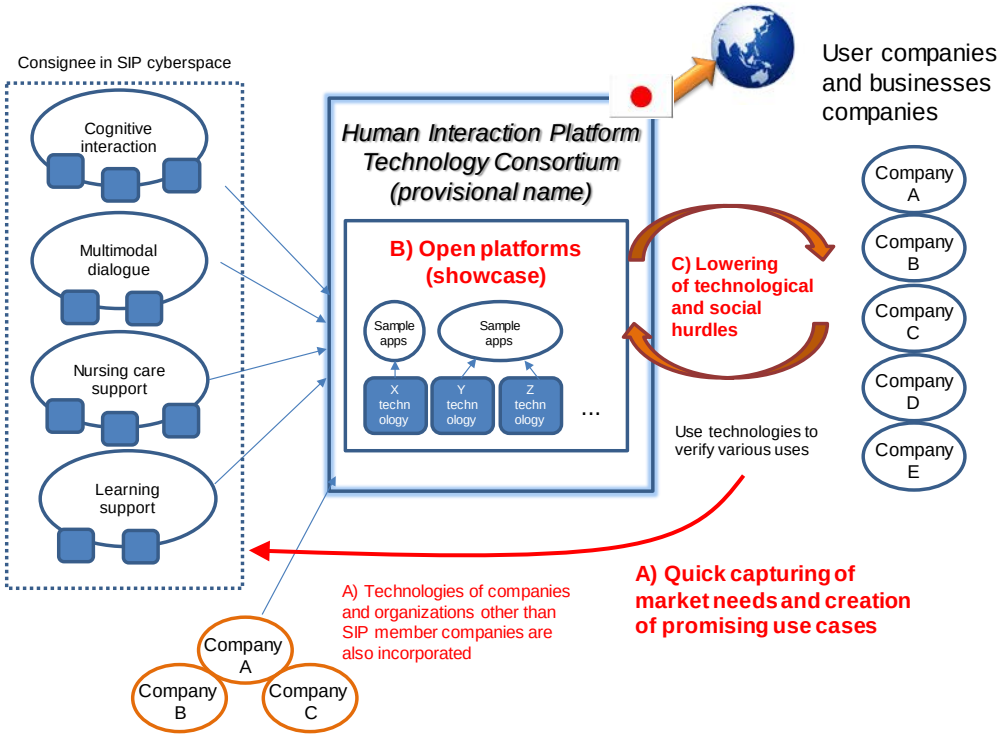

Figure 2-5. Open Innovation Strategy for Human Interaction Platform Technology

(1-1) Cognitive Interaction Support Technology

To realize a world in which humans and AI are highly collaborative, an advanced interaction support technology that supports human behavior and cognition will be developed by collecting and structuring non-verbalized information, such as eye gaze, facial expressions, postures, and gestures, that indicates human behavior and changes situations in various fields, making it reusable in various settings.

Specifically, (subjective/objective) human behavior and environmental information (e.g., things placed in the environment and information presented) are sensed from various sites to construct a database (cognitive behavioral characteristics database) that accumulates comprehensive data related to human behavior and cognition. In addition, a technology will be developed for designing and evaluating a multi-sensory information presentation method that anyone can intuitively understand, with appropriate amount and timing of information presented, to appropriately support human behavior and cognition using the cognitive behavioral characteristics database. A highly versatile and extensible standard format is defined for the cognitive behavioral characteristics database to allow its use across various fields. In addition, to apply the constructed cognitive behavioral characteristics database to cognitive and behavioral interaction

support for various tasks in various fields, safety and other evaluation methods will be established, and an evaluation system (technical evaluation platform) will be developed. Together with the research and development (R&D) of this platform technology, the practical applications where cognitive interaction support technology is effective are specifically identified and the clarification, prototyping, PoC model construction, and PoC evaluation of use cases for these practical applications (e.g., service industry, including customer services, and manufacturing industry) are conducted. The system development and operational maintenance for transferring the platform operation to the private sector will still be promoted after the end of this activity to effectively link the research and development (R&D) results to the practical and business application of this technology.
By using these platform technologies, productivity (calculated based on factors such as work time, learning speed, comprehension level, error rate, safety rate, or energy saving) will improve by at least 10% and safety will be ensured based on objective reasons.

● **Final Goals of Research and Development (R&D)**

To contribute to the realization of a society where people and AI collaborate by developing advanced technologies for human-AI collaboration that support human behavior and cognition and by creating practical applications.

[1] (1-1)-(i) Research and development (R&D) of Business Training and Support Systems Using Cognitive Interaction Support Technology fused with Artificial Intelligence (AI)

Head of research and development (R&D): Hiroshi Sato (Director, Human Informatics Research Institute, National Institute of Advanced Industrial Science and Technology)
Participating organizations: National Institute of Advanced Industrial Science and Technology, Chemical materials Evaluation and REsearch BAse, The University of Tokyo, Tohoku University, University of Tsukuba, Arblet Inc., and Digital Content Association of Japan (Note that the last two are subcontracted organizations.)

In this research, it is important to collect abundant data and create a database by gathering the behavioral information of people involved in business tasks and environmental information, and understanding the internal states of these people. The aim of this research and development (R&D) is to measure and understand cognitive interactions in actual business situations, including emotional aspects, using sensing technologies and ethnographic methods, and create a database for two or more business cases, mainly in interpersonal work contexts. An integrated pattern/symbol information

database is built with using artificial intelligence technology. This database is used as the basis to build a business training and support system that reproduces cognitive interaction at a work site using virtual reality and other technologies.

[Goals for this fiscal year]

- To create two use cases (airport lobby and restaurant service) for the "cognitive behavioral characteristics data information base."
- To construct a human interaction model that can be adapted to hospitality service scenes, with regard to cognitive functions.
- To generate training feedback information that realizes appropriate human interaction, using artificial intelligence technology with real-time capabilities.
- To establish a consortium with the anticipation of many companies joining the consortium, and set up committees such as the Business Model Committee, User Guidelines Committee, Open Innovation Platform Steering Committee, and Intellectual Platform Committee.

[Midterm goals] (as of the end of FY2020)

- To create a "cognitive behavioral characteristics data information base" ("task data information base") for the two applicable use cases and develop information platforms that can be used in a wide range of fields.
- To verify the effectiveness of the proposed method through PoC for the two applicable use cases.
- To establish the Human Interaction Platform Technology Consortium with over ten member companies.

[Final goals] (as of the end of FY2022)

- To create a task data information database for six companies, mainly in interpersonal work contexts.
- To create a practical application for the cognitive interaction support technology with the help of VR/AR/MR technology, conduct a proof of concept at six or more company sites, and confirm that productivity improves by at least 10% when all workers who perform the target tasks are trained with this technology.
- To establish the Human Interaction Platform Technology Consortium, and use the consortium's function to realize the social implementation of human interaction platform technology in 15 or more companies in the advanced personnel training, learning support, nursing care support, and other fields.

● Development theme 1: Creation of task description database

A task description database is created as part of the task data information base by measuring and analyzing work details, work environments, workers, and states of people and man-made objects affected by these workers and organizing them in conjunction with the psychological and physical states of workers.

● Development theme 2: Identification of business training and support issues, and creation of task data information base

Business training and support issues are identified based on the task description database for those that can be expected to have positive effects on worker motivation, effective work performance, and skills needed for effective work performance. Furthermore, a task data information base is created after structuring knowledge of the tasks.

● Development theme 3: Development of business training and support systems and evaluation technology

Business training and support methods are developed to drive worker motivation, provide a fulfilling work experience and effective work execution, and evaluation methods are developed to verify the effectiveness of these methods. Necessary sensor devices are developed at the same time. In addition, information of training and support methods created in the development of business training and support technologies and verification results of their effects is added to the task data information base.

● Development theme 4: Development of information display technology for business training and support

For this proposal, organic collaboration with the University of Tokyo's VR Education Center is realized, and an efficient information display for the business training and support and information feedback methods are developed. VR/AR/MR technology is used to assist in the development of the information display technology, and verification is conducted to clarify the information necessary and sufficient for realizing effective cognitive interaction.

● Development theme 5: Creation of guidelines for social implementation, promotion of standardization, and establishment of corporate partnership

A corporate partnership is created, mainly consisting of the companies participating in

this project but also including non-participating companies. This partnership surveys the needs of ten or more user companies, and conducts PoC to demonstrate the effectiveness of the system developed at the sites of user companies, and creates operational guidelines to extend the accomplishments of this project.
In addition, international standardization is conducted to create de jure standards for social implementation, with the possibility of applying the standards to advanced personnel development systems, learning support systems, nursing care support systems, and other technologies that are being developed.

● Development theme 6: Open innovation activities for social implementation of human interaction platform technology
For social implementation of the human interaction platform technology, a consortium (meta-consortium) will be formed to conduct social implementation of the results for this human interaction domain in the SIP. Also, an open innovation platform for the service industry will be constructed by encouraging the participation of companies and user companies that do business using advanced personnel development systems, learning support systems, and nursing care support systems and companies that implement improvements and field adaptation for the future.
The meta-consortium conducts activities that contribute to the following three open innovation platform matters:

A) Capturing of market needs (including the needs of technology development companies)
B) Open technology development for satisfying the needs
C) Activities that contribute to the lowering of social and business hurdles to the social implementation of technologies

[2] (1-1)-(ii) Cyber-Physical Manufacturing Industry that Contributes to Work-Life Balance
Head of research and development (R&D): Yasumichi Aiyama (University of Tsukuba)
Participating organizations: University of Tsukuba, Industrial Technology Innovation Center of Ibaraki Prefecture, CreaTact.Inc., and A-TECH Co., Ltd.

In recent years, there have been active discussions on the reemployment of the elderly, active participation of women, labor of foreign workers, and employment of persons with disabilities, to find solutions to labor shortages. However, the manufacturing industry is lagging in its efforts, due to its heavy work environment and work-life balance issues.

This research and development (R&D) attempts to develop a remote work system that supports physical work in cyberspace and solves the above problems. Specifically, there are two development themes in this activity. The first is the development of an AI system that automatically learns inspection methods and supports inspections performed by novices (AI inspection support system). The second is the development of a robot system that novices can easily control through cyberspace (VR teleworking system). This activity aims to identify necessary sensing information, create a data information base, understand how remote cognition works for humans and change the existing understanding based on findings, examine the development of a specific production system for improving productivity, and create attractive workplaces and comfortable home environments that are controlled by humans with AI providing congruent support.

[Goals for this fiscal year]

- To create a database for inspection items in the AI inspection support system and create an optimized design for the data preprocessing and machine learning algorithms
- To develop robot operation algorithms that use smartphones and VR tools (target accuracy of 2 to 4 mm when measuring robot motion, and operation time within 200% compared to on-site operation)

[Midterm goals] (as of the end of FY2020)

- To develop an AI inspection support system (e.g., distance measurement system, apps, and server software) (target of 5 to 6 inspections/minute)
- To decide which teaching method to use for the VR teleworking system and develop robot-related hardware (e.g., a robot hand and POV (point of view) camera) (target accuracy of 1 mm when measuring robot motion)

[Final goals] (as of the end of FY2022)

- To evaluate AI's automatic learning and recognition capabilities and evaluate timely stop systems for novice users (correct answer rate of 90% or more by AIs that support inspectors)
- To develop a robot monitoring app for remote factories
- To evaluate the VR teleworking system (good operator sensory evaluation score of 90% or more for remote operation)

● Development theme 1: Development of an AI system that automatically learns

inspection methods and supports inspections performed by novices
The goals for this theme are correct answer rate by AI of at least 90% and operator sensory evaluation score of 90% or more. In the practical application of AI, the correct answer rate must be 100%. But since this research is considered as a phase toward creating business applications taking into account the difficulties of human interaction and collaboration, the target correct answer rate is set to 90% or more. In addition, this system needs to be easy to use for inspectors, considering labor shortage and turnover issues. Sensory evaluations are conducted through questionnaires or other similar methods. The target is to develop a system with a favorable rating of 90% or higher by the operators.

● Development theme 2: Development of a robot system that novices can easily control through cyberspace
For this theme, the target favorable rating by the operators in the sensory evaluation shall be 90% or more. Similar to the system in development theme 1, the question of whether the users prefer to use the system developed in this development theme is also crucial. Although quantitative evaluations are performed based on diverse factors, including delays and screen resolution associated with remote operation, individual quantitative evaluation items differ for each operator. Response delay is often influenced by the communication environment. Therefore, the target evaluation value is based on the operators' satisfaction and their preference to use the system.

[3] (1-1)-(iii) Development on skill transfer of professional engineers and advanced scanning devices in infrastructure management

Head of research and development (R&D): Satoshi Wada (RIKEN)

Participating organizations: RIKEN, National Institutes for Quantum and Radiological Science and Technology, Keisokukensa. Co., Ltd., and Association for Promotion of Infrastructure Geospatial Information Distribution

The aim of this research and development (R&D) is to provide possible solutions to the problems of the shortage and aging of talented engineers supporting Japanese infrastructure. Specifically, the "scientific analysis of techniques used by skilled engineers and the reconstruction of the decision-making process for use in AI (engineering-supported precursor diagnosis AI)," "creation of an education system for entry-level engineers," and "implementation of engineering-supported precursor diagnosis AI as device embedded software" for infrastructure measurement devices

developed in the first phase of SIP are conducted, and the Cyber Physical System (CPS) type social implementation for infrastructure inspection to be realized in Society 5.0 is carried out through organic collaboration between final judgments made by humans and support systems.

[Goals for this fiscal year]

- To establish the concept of engineering-supported precursor diagnosis AI and study the method of introducing cognitive interaction support technology in the infrastructure maintenance and management domain
- To verify the method of acquiring engineer movement data, design the crack specifications necessary for creating training materials, acquire sample data, and identify issues
- To examine the method of identifying defects using images and laser-hammering measurement data
- To identify the issues regarding data utilization and operational considerations for the data platform development

[Midterm goals] (as of the end of FY2020)

- To establish a proof based on concrete engineering for hypotheses posed by skilled engineers in the infrastructure maintenance and management domain, and create an image-based crack identification system with an accuracy of 80% or higher and a laser-hammering defect assessment system with a defect matching rate of 90% or higher, comparable to the identifications made by professional engineers
- To create a prototype data platform and conduct trial operation through cooperation with the local government

[Final goals] (as of the end of FY2022)

- To complete the creation of an AI system that matches the decisions of skilled engineers with an accuracy of 90% or more with respect to an actual tunnel in close-up visual inspection in the infrastructure maintenance management area and deploy it in the robot inspection system
- To establish an image-based danger assessment technology that matches the decisions of skilled engineers with an accuracy of 80% or more for 0.3 mm or wider cracks, and laser-hammering inspection technology that can be used to carry out road tunnel inspection procedures

- To create the data exchange platform technology necessary for various AIs and systems ("engineering-supported precursor diagnosis AI system", "defect judgment system" and "danger assessment system") to support cognitive interaction in the infrastructure maintenance and management domain and conduct a trial of two-way linkages with external systems

● Development theme 1: Research and development (R&D) of analysis and systematization of professional skills in infrastructure maintenance domain
The professional skills in infrastructure maintenance is analyzed, and research and development (R&D) is conducted on engineering-supported precursor diagnosis AI system that recreates professional engineers' decision-making processes on the basis of scientific evidence.

● Development theme 2: Development of scientific-supported education system for infrastructure maintenance
An education system that codifies the expertise of professional engineers using civil engineering, concrete engineering, and other scientific methods is developed.

● Development theme 3: Research and development (R&D) on high accurate extraction of dangerous areas through image measurements
A system for identifying dangerous areas from captured measurement images on the basis of reconstructed judgments of professional engineers, is developed using concrete engineering and civil engineering methods.

● Development theme 4: Research and development (R&D) of the precise diagnosis of internal defect in the lining concrete by using laser-hammering method
A laser-hammering defect assessment system is developed, which combines the results of internal defect measurements taken with laser-hammering measurement technology developed in the first phase of SIP and the results obtained using the image instrumentation system.

● Development theme 5: Research and development (R&D) of the database platform for infrastructure maintenance
Research and development (R&D) is conducted on data platforms that store and utilize data obtained with measurement systems.

(1-2)Advanced Multimodal Dialogue Technology

The aim of this technology is to enable highly intelligent multi-modal dialogues between human and machines. Particularly, it will enable not only scenario-based multimodal conversations but also flexible chitchat capabilities by leveraging the enormous amount of knowledge, and information accumulated in the internet. This technology exploits a technology platform enabling advanced multimodal communication, as well as large-scale linguistic resources and deep learning technologies. This project covers the research and development (R&D) of those technologies and aims at the creation of innovative services and businesses that transcend existing industrial structures and technologies by integrating both verbal and non-verbal information.

In addition, this project aims to create practical applications (e.g., nursing care, urban space service innovation, smart mobility on-board communication, and education) where the social implementation of advanced multimodal dialogue technology can be leveraged. Evaluation of the effectiveness of the technology in such use cases will be conducted through prototyping, PoC model development, and experiments in the target domain/application fields. The sharing/distribution schemes for linguistic resources and other technologies are being examined, and the community for sharing the technologies will be established.

● Final Goals of Research and Development (R&D)

Contributing to solving big social issues and enhancing industrial competitiveness through intelligent multimodal dialogues, which are enabled by the combination of multimodal communication technologies, manually-prepared dialogue scenarios and intelligent chat systems that exploit advanced deep learning technologies, a huge amount of knowledge, and information available in the internet.

[1] (1-2)-(i) A Hybrid Multimodal Dialogue System Combining Big Data on the Internet and Application
Specific Dialogue Scenario
Head of research and development (R&D): Yasuhiro Takishima (KDDI Corporation)
Participating organizations: KDDI Corporation, National Institute of Information and Communications Technology, NEC Solution Innovators, Ltd.

The goal of this project is to develop advanced multimodal dialogue system that can execute a given task (i.e. the "primary goal"), based on controlling multiple dialogue

modules, such as goal-oriented scenario-based dialogue and large-scale data-driven dialogue (chat). In addition, the establishment of a developers' community and the disclosure of fundamental technology are also targeted for the extensive utilization of the results of the R&D conducted in this project.

In the field of long-term care for the elderly, the following objectives are set:

- ✓ 80% of required information (for long-term care for the elderly) can be collected through the dialogue with the advanced multimodal dialogue system to achieve the primary goal for goal-oriented dialogue.
- ✓ Achieve 70% ratio of appropriate response generation to user utterances for hybrid dialogue, i.e., the combination of goal-oriented dialogue and non-task-oriented chat.
- ✓ Achieve significantly higher user satisfaction for the hybrid dialogue, in comparison with using only goal-oriented dialogue.
- ✓ Build a developers' community that includes more than five startup companies and long-term care service business operators.

Evaluation experiments will be performed in stages to verify the usefulness of the dialogue system developed through this project to achieve the objectives listed above.

[Goals for this fiscal year]

- To build a dialogue scenario group for long-term care that includes 6,000 questions to implement goal-oriented dialogue
- Development and initiation of the advanced multimodal dialogue system
- To conduct a small-scale demonstration experiment of the advanced multimodal dialogue system in the field of long-term care

[Midterm goals] (as of the end of FY2020)

- To build linguistic resource consisted of 350,000 items
- To develop identification technology for personal characteristic information that fully utilizes the multimodal sensing information of images and sound
- To develop technology to switch naturally between scenario-based dialogue and the web-based chat Q&A module, which is one of the large-scale data-driven dialogue modules to be developed in this project

[Final goals] (as of the end of FY2022)

- To build linguistic resource consisted of 700,000 items
- To develop predictive processing technology for prompt acquisition of emotion from users' facial expressions, voice, gestures, and body surface temperatures (in order to confirm that the progress of dialogue is appropriate, and the emotion of the system user improves through the deduction of emotion.)
- To develop deep learning techniques that respond to and interpret complicated questions from users (and confirm that 80% of required information (for long-term care for the elderly) can be collected to achieve the primary goal for goal-oriented dialogue, along with the other achievements of research and development

● Development theme 1: Advanced multimodal dialogue platform

We will develop a platform to materialize an advanced hybrid multimodal speech dialogue system. The hybrid system is based on "goal-oriented dialogue module" that uses dialogue scenarios that are particular to the application areas, such as long-term care for the elderly, and a "large-scale, data-driven dialogue module", which handles various inputs that cannot be handled by the goal-oriented dialogue system and enables flexible responses to user utterances, i.e., non-task oriented chat. This will be done using various information and knowledge including those available on the Internet.

● Development theme 2: Building of large-scale linguistic resources and advanced dialogue / natural language processing technology using deep learning

We will develop a semantic interpretation module for user utterance and an automatic scenario expansion module that specially requires utilization of deep learning, and tune "WEKDA," the speech dialogue system of NICT. These will then be incorporated into the multimodal speech dialogue system, which will be the final outcome of this project. Also, we will build large-scale linguistic resources that include the learning data and dictionaries required in the development of the module, tuning of the system, and analysis modules for back-end DBs developed in other themes.

● Development theme 3: Advanced multimodal dialogue interface technology

We will process the multimodal information utilized in the above-mentioned advanced multimodal speech platform, and materialize an advanced multimodal speech interface that includes technology to deduce user emotional state. In this theme, we will deal with the processing of information such as the voice/sound/video (image) input from the microphone/camera, which is assumed to be the dialogue system interface, and the

dialogue log. We will also deal with analysis processing such as the backend DB, which is necessary for the care managers and long-term care business operators to perform operations, and modality such as the speakers/display used as the output interface.

● Development theme 4: Dialogue scenario building technology for long-term care
We will design and implement dialogue scenarios that are required in the specified application area. For the implementation of dialogue scenarios, we will not only rely on hand-made scenarios that are designed by professionals in the target field, but also expand the dialogue scenarios using crowd sourcing. Furthermore, we will take comprehensive measures for unexpected user utterances by providing an automatic extraction function for insufficient context conditional branching.

● Development theme 5: Evaluation and verification for building a community with startup companies and others
In this project, in addition to the building of the dialogue technology itself, we will build a development community with startups and other related companies. Namely, in order to expand the range of applications of the dialogue technology, we will evaluate (1) technology to utilize sensor information other than video/voice, and (2) the acceptability of advanced human-like user interfaces. Through this evaluation, we plan to establish a community that includes startup and other companies.

(1-3) Learning Support Technology

To evolve the relationship between school education and the stage of learning in the era of Society 5.0, we will make it possible to reproduce the experience and educational skills of experienced teachers using AI technology, and based on the evidence, aim for tailor-made learning that matches the characteristics of each individual (learner). Specifically, we will collect and accumulate the big data of school education, and by combining this with AI technology, we will analyze and optimize the existing learning and teaching method to develop a system that provides appropriate learning contents, customized to match the characteristics and degree of achievement of each learner. In addition, we will perform real-time analysis of the bidirectional interaction between the teacher and learner and the learner and AI, to develop a system to send feedback to teachers about learners' characteristics, their degree of understanding, and their ability to concentrate, to help support the teachers.

We will also consider a system for the safe management and operation of education

big data that have enormous amount of personal information, and develop the platform technology necessary to spread tailor-made learning.

In order to advance toward Society 5.0, to develop human resources who can produce innovative world-class business models based on globally advanced information technologies such as AI technology, it is important to master fundamentally required abilities such as the basic imaginative power and ability to find and solve problems that facilitate data analysis, and the ability to think until the point of the argument is clear and to make a decision. Therefore, in this technology development, we have set our targets on the following two subjects: "Mathematics," which is valuable for improving ability to clearly understand the composition of things and achieve goals, and "English," which is valuable for improving the world-class ability to think until the point of the argument is clear, make a decision, and describe. The target schools for demonstration will be junior and senior high schools, where active and continuous participation may be expected for the collection of big data and introduction of AI technology.

For the research and development of this domain, consider the utilization of research results for advanced cognitive interaction support technology that supports human and AI cooperation (development item (1-1)), and advanced multimodal dialogue technology (development item (1-2)).

● Final Goals of Research and Development

To create the infrastructure for EdTech as a new industry, through the proposal of learning methods customized to the characteristics and degree of achievement of each learner, and to use AI technology to make available new education technology to send real-time feedback of learners' conditions to the teacher.

[1] (1-3)-(i) Research and Development of Tailor Made Education Based on Evidence

Head of research and development (R&D): Kazuo Hiraki (National University Corporation, the University of Tokyo)

Participating organizations: The University of Tokyo, Kyoto University, Nippon Telegraph and Telephone Corporation, NTT Communications Corporation, NTT Learning Systems Corporation (hereafter recommissioned) Assemblogue, Inc., Keio University, Kyushu University

To realize fair and individually optimized learning support, we will build a pedagogical information platform organically integrating learning cognitive science, artificial intelligence (AI), and information infrastructure technology. Our aim is to improve the

academic abilities of students in elementary school and junior and senior high schools in English and Mathematics (Math). Specifically, we will accumulate the learning log data of 2,000 students for an extended period of time, including interaction data between the student and the teacher in school, and learning history on a mobile device. Then, using similarity matching and other methods, we will build a system that proposes the most appropriate learning materials and learning methods. In addition, we will build a mechanism to protect personal data, which becomes an issue when implementing Study log in a wide area, and a data infrastructure that allows the new entry of startup and other companies.

The goals of this research and development are to reduce the workload of Japanese teachers, who are considered the busiest teachers in the world, by 10% or more, and to improve the learning effect in Mathematics and English demanded in the era of Society 5.0 by 20% or more, through the implementation of Tailor Made Education. By spreading and deploying these research and development results to the entire society, it will be possible to generate many practical examples that create new values in the field of education for the materialization of "Society 5.0."

[Goals for this fiscal year]

- To collect/analyze the learning big data (*the Study log of teachers/students acquired in the experimental schools) of 2,000 people
- To collect/analyze the teachers/students in some of the experimental schools(more than 100 people)
- To develop prototypes for the LRS (Learning Record Store) of Study log
- To establish common specifications of Study log
- To create a guideline draft regarding data portability of Study log

[Midterm goals] (as of the end of FY2020)

- To collect deep data for more than 100 people (*deep Study log acquired in the laboratory) and learning big data (*the Study log of teachers/students acquired in the experimental schools) for more than 2,000 people
- To establish standards for Study log
- To develop a pedagogical AI (learning method feedback application based on Study log) prototype

[Final goals] (as of the end of FY2022)

- To complete the development and commercialization of LRS (Learning Record

Store)/PLR (Personal Life Repository)

- To improve the learning effect by 20% and to reduce the teacher workload by 10%, through the experiment of experimental schools by the pedagogical AI
- To establish data sharing guidelines/anonymization guidelines

● Development theme 1: Collection of evidence, and research and development of learning support based on evidence

- Research and development to make interactions between teachers and learners into Study log

  Mainly in English and mathematics, we will clarify the collected data items and their effectiveness in collecting and accumulating Study log of learners (assuming students of elementary schools and junior and senior high schools) in class and home.
- Research and development to implement effective learning support by classifying the changes in degree of understanding through learning support

  We will research and develop a mechanism to support learning (method, contents, frequency, and timing) based on each learner's degree of understanding and characteristics of thoughts, through classification using the cognitive science approach, analyzing Study log accumulated on the pedagogical information platform.

● Development theme 2: Research and development for materialization of a pedagogical information platform and social implementation

- Research and development of a pedagogical information platform for the collection, accumulation, and analysis of Study log

  We will research and develop an ecosystem (a pedagogical information platform) that can be shared as a research and development infrastructure, not only with teachers but also with cram schools, startup companies, education administrative officers and others, with appropriate permission for data modification and consent such as agreements
- Research and development of information management for the social implementation of the learning support mechanism

  We will consider the use case where Study log are utilized efficiently, determine the areas where cooperation is necessary to accelerate data distribution, and establish standards. In addition, we will research and develop procedures and operating rules for data acquisition/storage/sharing and so on, taking into consideration personal data protection legislation and education information security guidelines (by MEXT)

for social implementation.

[2] (1-3)-(ii) Promotion to Introduce Education Support Based on Big Data for High-Precision Education into Public Education

Head of research and development (R&D): Takafumi Terasawa (Okayama University)

Participating organizations: Okayama University, (hereafter recommissioned) Uchida Yoko Co., Ltd., Ask Publishing, Tohoku University, Miyagi University of Education, Kyoto University, Hyogo University of Teacher Education, Naruto University of Education

The learning effect visualized by big data for high-precision education increases steadily even in children with low academic ability, and it is starting to be verified that the motivations of those children who have lost motivation and given up are improved by receiving the feedback. There are also some situations where various objective information that were demanded in the field of education but could not be obtained are extracted from the big data.

This project allows the current model system to be applied nationwide, and by upgrading to a more secure system, it aims to quickly expand throughout the society the customized learning support that mainly supports the vocabulary acquisition of individuals ranging from elementary school students to adults, and to enhance the vitality of individuals. In addition, this will return newly revealed results quickly to the society.

[Goals for this fiscal year]

- To conduct a demonstration experiment with 4,000 people using systems existing in elementary schools, senior high schools, and universities as experimental fields. To collect basic data by operating the WEB feedback system
- To complete the copyright process for the learning contents for vocabulary acquisition
- To develop a sample prototype system for a learning system device incorporating game elements
- To implement a system on mobile devices that can restrict network connection when the device is taken home from school, to collect experimental data using the device, and identify issues
- To identify issues that are estimated to be a skill level where learning is no longer needed, and to apply adaptive learning to remove them from the learning target.

[Midterm goals] (as of the end of FY2020)

- To conduct a demonstration experiment on 5,000 students in elementary schools, junior and senior high schools, and universities. To verify the developed functions and to design a mechanism to understand the learning state of a group of learners, such as a class or a school, by the instructors, such as teachers.
  - To conduct a demonstration experiment on a mechanism for individuals to receive feedback data without saving personal feedback data and email addresses on the same network system
  - To complete a mock learning/feedback system incorporating game elements, and to conduct a demonstration experiment using demo data without using the Internet
- To achieve a 10% or more increase in the scores of children who had been having low scores, in the index that indicates interest in independent learning behavior
- To implement a mobile device in a grade unit in an elementary school or junior high school using an access-restricted program software, and to execute new e-learning for more than half a year.
- To design and develop a model system of an advertisement mechanism that supports events that display advertisements such as for a "free french-fried potato coupon" or a "free coffee coupon" corresponding to an increase in performance (when one stage is finished), in a game element-like mechanism.

[Final goals] (as of the end of FY2022)

- To conduct a demonstration experiment with 10,000 people in elementary schools, junior and senior high schools, and universities that are the demonstration experiment sites (education sites) and perform the newly developed function
  - To implement a mechanism for individuals to receive feedback data, without saving personal feedback data and email addresses on the same network system
  - To implement a system that interlocks the learning/feedback system with incorporated game elements and the big data of high-precision education system
  - To implement a system that monitors the learning state and consciousness of learners per class or school
- To achieve a 10% increase in learning volume for senior high school and university students 2 months after starting the study, due to the introduction of a system that incorporates game elements
- To achieve a more than 20% increase in the scores of children with low scores, in the index that indicates interest in independent learning behavior
- To improve significantly performances in vocabulary and general tests in comparison with the case where this support is not introduced
- To build a situation where elementary school and junior high school students can

learn inside and outside of the school in an environment unaffected by Internet issues, using mobile devices installed with software that enables access restriction, purchased by each family

● Development theme 1: Building and operation of a learning data/information platform and learning support system that generate advanced learning effect

We will build a storage system that can acquire and back up various learning data on a large scale by FY2020, and build an information platform that can centrally execute attitude surveys and provide longitudinal data as completely anonymous data by FY2022.

● Development theme 2: Building and operation of a secure learning data/information platform taking into consideration privacy protection

We will build a mechanism to enable learners to receive feedback data individually by FY2021, without placing feedback data and email addresses on the learning/feedback system, using a new patented technology called the T-code communication principles.

● Development theme 3: Realization of an Advanced Learning Support System Promoting Customized Learning

A method has already been established for observing the learner's reaction at a fixed point, accurately measuring the ability, and accurately estimating the degree of achievement for each learning issue from the time change data. Based on this method, we will identify an issue under this project that is estimated to be at a skill level where learning is no longer needed, and build a mechanism to remove it from the learning target.

● Development theme 4: Construction of a New Learning Model Based on Practice That Integrates R&D of Cognitive Science, Psychology and so on, with the Field of Education and a Variety of Educational Fields, as well as its Development into Society

Memories corresponding to the knowledge that underlies ability test results are called implicit memories, and their characteristics are very different from general memories (explicit memories). For example, it has become clear that the ability (implicit memory) is surely built up even by learning through skimming, and in the case of English words, the effect of repeatedly learning the same word more than 5 times a day is not accumulated in the achievement level and so forth. In addition to disseminating such new knowledge to the general public, we will develop a scheduling system that visualizes emotional growth in collaboration with practitioners with the aim of developing new theories regarding emotional growth such as motivation, independence, and sociality.

● Development theme 5: Clarification of Model and Human Resource Development for Content Companies to Replace Information Companies
The aim is to show that the current royalty business model will be reborn into one where companies provide information services.

● Development theme 6: Establishment of a Mechanism for Managing the Operation of Big Data for High-Precision Education
A new mechanism will be required where the advantage of using collected big data for high-precision education is returned to educational service and so on. A startup company that provides this service will be established in FY2020, and in the latter half of research and development (R & D) (FY2021), which will clarify the stakeholders for data usage, a preparation organization will be set up to establish an organization that will examine data usage rules and restrictions.

[3] (1-3)-(iii) Tailor-made Learning support by Design of Thinking Experience Based on Symbolic AI and Detection of Thinking Pattern Based on Statistical AI

Head of research and development (R&D): Tsukasa Hirashima (Graduate School of Engineering/School of Engineering of Hiroshima University)
Participating organization(s): Hiroshima University, (Re-consigned by) Yamaguchi University, Hiroshima Institute of Technology

We model Cognitive science and psychological knowledge about human thinking based on symbolic AI, and build a learning environment that learners can externalize their thinking and explore it using ICT technology. The learner's activities in this environment are thinking experiences for the learner, and learners are expected to learn thinking styles through the experiences. Furthermore, we detect thinking patterns of learners from learning logs as the change of the external representation reflecting learners' thought. Change of external representation can be recorded as sequence data, and statistical AI can extract sequence patterns. Based on the extracted thinking patterns, Tailor-made learning support in responding to individuals can be realized. Its usefulness will be demonstrated in educational settings.

[Goals for this fiscal year]

- To use learning support environments based on the kit-build method and collect data at schools

- To detect thinking patterns from the manipulation process of external representation
- To consider Tailor-made learning support based on thinking patterns

[Midterm goals] (as of the end of FY2020)

- To develop prototype systems of learning environment based on the kit-build method
- To design and develop real-time learner activity monitoring systems that collect learner activities in the proto-type systems and that provide them to teachers, and to evaluate the monitoring systems based on workshops for teachers
- To develop a function that extracts pattern extraction from collected thinking experience data based on statistical AI
- To implement a learning content recommendation function based on learning history and thinking patterns
- To conduct the trial use of learning environments at home

[Final goals] (as of the end of FY2022)

- To integrate subsystems using an agile development method
- To conduct small-scale experiments at some schools
- To analyze learning effects based on academic results, conditions in learning based on biological information, and subjective evaluations based on questionnaires and interviews.

● Development theme 1: Design and Sensing of Thinking Experience based on Symbolic AI

We model thinking as the manipulation process of external representations in symbolic AI approaches. The base of the modeling is a graphical representation of concept associations such as semantic networks that have been used for a long time in knowledge engineering. Learners organize the information he/she has obtained as such a graph structure and express it on the computer as an external representation. And then, they check the validity of the structure, compare the structures for confirming the difference between them through assembling, changing, and manipulating the structures shown as the external representations. These activities will be conducted as the interaction between the external representations on the learning environment and internal representations in learners' minds. Therefore, the design of the external representation of thought and manipulation of the representation can be the design of

the thinking experience, and the record of the manipulation process can be the record of the thinking experience. We adopt the kit-build method as the basis for the environment where learners create and manipulate external representations of thought. In the kit-build method, learners can directly manipulate the predefined parts and relationships to describe the internal representation as the external representation. The environment has the automatic diagnosis functions about the correctness of the external representation created by the learner. It also has the functions to collect the learners' manipulation processes of external representations as sensing of the thinking experience in real-time and visualizes them for the teacher.

● Development theme 2: Detection of Thinking pattern on the Basis of Statistical AI
In order to use the data acquired in the externalization environment for learning support, we detect patterns of the manipulation process of external representations obtained in development theme 1. The pattern detection is conducted in the following two purposes: one is whether or not the patterns that can be considered in advance from the components defined beforehand in the kit-build method actually appear, and the other is whether or not the patterns other than those considered in advance actually exist. For these purposes, we detect patterns statistically from the transitional data of external representations. The detected patterns are defined as thinking patterns based on the thinking experience model. The thinking patterns are verified by comparison with the judgment by the teacher. Moreover, they are also verified by linking with biological data such as brain wave data and eye movement data and explaining them with brain functions and eye movements.

● Development theme 3: Tailor-made Learning support Based on Thinking patterns
By combining the thinking patterns acquired in development theme 2 with the learning environment designed in development theme 1, we realize Tailor-made learning support that matches each learner's thinking experience. Specifically, the thinking patterns detected from the thinking experience of learners are used to provide advice and to recommend learning content according to the characteristics of thought of each learner. We will verify the validity of this Tailor-made learning support by comparing it with teachers' judgment on thinking experience data. We will also improve the method based on the verification results. Its effects will be verified through classroom use in schools and home use.

● Development theme 4: Portable and Secure Distributed Data Management

In order to use thinking experience data recorded in various situations for the use of learning content provided by various institutions, it is required that individuals can possess the data and used safely without spoofing or tampering. Block chain is expected as the platform for operating data in such a secure and portable manner. Block chain both manages data in a distributed manner and ensures that there is no tampering or loss. We use it for managing data on learning history and material updates. This sort of data management makes it possible to use data seamlessly between inside and outside of the classroom, such as at home, and teachers also know the conditions. Moreover, it will be able to provide learning opportunities not only in schools but also outside the school. In this research theme, we will select available systems, design data with a view to managing thinking experience data accumulated and utilized for Tailor-made learning support based on thinking patterns and incorporate them into the learning environment without newly developing a portable and secure distributed type data management system based on block chain.

(1-4) Nursing Care Support Technology

By collecting, accumulating, and utilizing various data related to nursing care from the field and combining them with AI technology, we will develop a platform technology for nursing care that is effective in curbing social security costs and realize a platform for measuring effectiveness.

Specifically, (A) interaction-based indicators using AI (structured/unstructured data of medical/nursing care that can be newly acquired by sensors, actuators, and so on, and analysis results on its multimodality), (B) medical science-based indicators (care receiver-related; QOL, behavioral psychological symptoms, ADL, IADL, and so on/caregiver-related: caregiver burden scale, and so on), and (C) the causal relationships among the three indicators, i.e. economics-based indicators (care receiver-related: degree of care, care expenses/caregiver-related: employment rate, turnover rate, unit cost of employment, total professional caregiver supply in labor market) are accumulated as evidence to develop a platform capable of analyzing the relationship between microscopic medical science-based indicators and macroscopic economics-based indicators, and outputting the effect of applying AI technology as a correlation with various indicators.

In obtaining the above evidence, local governments, hospitals, long-term care facilities, IT-related companies and AI startups will collaborate to establish a platform which will allow comprehensive demonstration experiments on value chains to be conducted in relation to the entire nursing care service with a view to evaluating intervention measures

in the nursing field newly created by the development of AI technology, and disseminating/deploying measures evaluated as effective nationwide and across overseas markets.
As regards research and development (R & D) in this field, utilization of the research result of advanced cognitive interaction support technology (development item (1-1)) and advanced multimodal dialogue technology (development item (1-2)) that support human-AI collaboration will be considered as well.

●Final Goals of Research and Development (R&D)
To develop AI technology that can reduce social security costs by 10% or more against nursing care costs expected to be 20 trillion yen in 2025, and to realize a platform that can quantitatively measure the effects.

[1] (1-4)-(i) R&D and Social Implementation of AI Supporting Independence and Co-Existence through Multimodal Human Interaction Technology that “Is Focused on the Perspective of the Person with Dementia and the Person’s Family”

Head of research and development (R&D): Ko Ishiyama (President and Representative Director of ExaWizards Inc.)
Participating organization(s): ExaWizards Inc., Shizuoka University, Keio University, Designing for Dementia HUB, National Hospital Organization Tokyo Medical Center, Society of Citizen Informatics for Human Cognitive Disorder

Stakeholders in the nursing field centered on persons with dementia (the person/family) and AI technology will be highly coordinated to build human interaction technology that supports the person's independence. Specifically, multimodal memory, integration, cognition, and behavioral expression models related to care and dialogue processing technology will be developed for AI prototyping for independence/co-existence support to understand and express the state images of people with dementia and their relationships with others. In addition, about 20 local governments will conduct demonstration experiments of AI coordinated with IoT devices, sensors, and subjective information. By building up an evaluation infrastructure which integrates AI-related interaction-based indicators, medical science-based indicators, and economics-based indicators through various demonstration experiments, and by widely and deeply collecting, as well as horizontally opening and expanding evidence and empirical/scientific knowledge which will reduce social security costs and improve the QOL of the parties concerned, it is aimed to create “Inclusive Innovation” in which various

“parties” participate in the entire social system. Furthermore, we aim to create new industries through the use of such AI and to develop them into global markets.

[Goals for this fiscal year]

- To conduct a demonstration experiment with full lineup in Kanagawa Prefecture (Kamakura City)
- To develop AI technology to infer the target from collected data
  - Automatic determination of context that can be used in general for dementia such as “see, speak, and touch”
  - Automatic judgment of individual contexts such as “beer tooth brushing” and automation of intervention
- To develop multimodal independence/co-existence support corpus by the Society of Citizen Informatics for Human Cognitive Disorder

[Midterm goals] (as of the end of FY2020)

- To complete the AI data infrastructure
- To have demonstration experiments conducted by local governments (7 local governments or more)
- To start the test on result-linked type private consignment contract (one local government or more)

[Final goals] (as of the end of FY2022)

- To have 1.2 million users of personal support AI and family support AI
- To start the third-party use of developed infrastructure
- To accumulate cases of overseas deployment

● Development theme 1: Strategic Infrastructure (Infrastructure-Based Theme (i))

Currently, while a variety of services have begun to be provided in relation to “care×AI,” the entire picture of AI utilization opportunities in the value chains of care services (presymptomatic disease – care – deathwatch), the direction of efforts by central government/local governments, hospitals/long-term care facilities, and AI companies/research institutes, and the way to success of “care×AI” in Japan are being clarified. In the future, a strategy will be formulated with a view also to globally deploying the successful model of “care ×AI” in Japan.

● Development theme 2: Data Infrastructure (Infrastructure-Based Theme (ii))

It is aimed to establish a data collection infrastructure for acquiring evidence from efforts by the central government/local governments, hospitals/long-term care facilities, and AI companies/research institutes. In establishing evidence, under the collaboration of local governments, hospitals/long-term care facilities and IT companies/AI companies, we will build a platform which will allow comprehensive demonstration experiments to be conducted for value chains in the entire care service. In designing the data acquisition method, after clarifying the roles and positions of a database on existing care areas, the utilization and linkage of other databases will be proactively considered. Particularly, we will actively obtain the data that can be newly acquired through the development of AI/IoT technology, and, in view of the coordination with 'multimodal independence/co-existence support corpus,' we will proceed with the organization of data items targeted for analysis.

● Development theme 3: Evaluation Infrastructure (Infrastructure-Based Theme (iii))
It is aimed to design an objective evaluation framework for evaluating various evidences collected in the data infrastructure. Based on the evaluation framework and evaluation indicators, we will evaluate the results of each demonstration experiment, and formulate a nationwide dissemination/overseas market deployment plan for measures (best practices) evaluated as effective. Then, we will analyze the relationship between microscopic medical science-based indicators and macroscopic economics-based indicators, and establish a PDCA cycle which will allow social security costs to be contained. Additionally, in the visualization of interference effect, the interference effect which have been found difficult to verify in the past will be visualized by using AI to make a prediction from acquired data, and comparing the differences between the prediction result and the interference result.

● Development theme 4: System Design Infrastructure (Infrastructure-Based Theme (iv))
On the basis of the evaluation result obtained by the evaluation infrastructure, we will formulate proposals for required system design and system change.

● Development theme 5: Understanding/Expressing the State Images of Persons with Dementia (Personal Support AI) (Demonstration Experiment-Based Theme (i))
In order to estimate and objectivize the state images of the parties that cover everything from personal profiles with little fluctuations to life information with great fluctuations, we design information models for thoughts, emotions, and bodies. The activity of collecting various types of data covers everything from objective data using IoT devices and various sensors to subjective data obtained by a panel survey of thoughts and

experiences in our daily life.

● Development theme 6: Enhancement of Care Interaction, Life Environment Design, and Diagnosis Through the Use of Cooperative Learning System
We will design an information model ‘Care Interaction Model’ that expresses the interaction between the person and others (family members, care professionals such as nurses and care workers, living space and environment), and conduct AI development/demonstration experiments to support living environment designs and creation of environments/fields suitable for individuals.

● Development theme 7: Transformation of Network Structure and Society from a Macroscopic Perspective (AI Utilization Community)
We will conduct an evaluation of changes in macroscopic/wide-area social acceptability and regional change for dementia care initiatives utilizing AI, and demonstration experiments leading to the design of incentives for local governments utilizing AI.

[2] (1-4)-(ii) R&D of Japanese Style ICT Community Comprehensive Care Model integrated with Telemedicine AI

Head of research and development (R&D): Teppei Sakano (President and Representative Director of Allm Inc.)

Participating organization(s): Allm Inc., the Jikei University School of Medicine, Nippontect Systems Co, .Ltd., Data Section Co.

Utilizing ICT infrastructure in a community’s comprehensive care fields, we will conduct the research and development (R & D) of monitoring AI and telemedicine AI through the coordination and collection of data from various wearable IoTs and medical devices. In addition to smart apps and tablets carried by professional caregivers and nurses to support daily operation, we will realize improvement of productivity by means of developing human interaction AI integrated with monitoring AI and telemedicine AI. The three AI will enhance caregivers to incorporate with medical experts by utilizing timely observation data such as vital data and message between caregivers and nurses from the work data obtained at care/nursing fields suffering from chronic labor shortage. The overall system is to be provided to the global market as the Japanese style model of cutting-edge care/nursing/medicine integrated with AI thru comprehensive community care ICT.

[Goals for this fiscal year]

Development theme 1: To implement the test operation of linked devices at an in-home care site and complete linked development

Development theme 2: To implement the research and development (R&D) of an ECG analysis (abnormality detection) model

Development theme 3: To hold expert meetings and design clinical trials for dementia diagnosis and efficacy evaluation tools

Development theme 4: To develop an input interface for behavioral symptoms of dementia and feedback to caregivers to be realized through Team

Development theme 5: To create accounts of nursing efficiency and medical cost reduction

[Midterm goals] (as of the end of FY2020)

Development theme 1: To complete an improved medical devices program working in coordination with comprehensive community care ICT

Development theme 2: To conduct data capture from home-care medical devices (ECG monitor), AI analysis on accumulated data, and trial operation of monitoring AI at a facility

Development theme 3: To conduct clinical trials to collect the data necessary for diagnosis of dementia on 30 patients

Development theme 4: To conduct the evaluation of a β version of interaction AI by professional caregivers and care managers

Development theme 5: To explore and research business improvement algorithms, and conduct simulations based on hypotheses

[Final goals] (as of the end of FY2022)

Development theme 1: To start sales of linked products and implement product improvements based on post-marketing data

Development theme 2: To start sales of the product version of monitoring AI linked with community comprehensive care ICT

Development theme 3: To complete the product version of telemedicine AI (diagnosis of dementia) and FDA approval process

Development theme 4: To complete and launch the product version of Human Interaction AI

Development theme 5: To conduct empirical research on approaches to reduce medical and nursing costs

● Development theme 1: Research and Development (R&D) of the Networking of Medical Devices

Realize information linkage with vital monitors at home and long-term care facilities with “Team”, a comprehensive community care ICT, used as infrastructure.

● Development theme 2: Research and Development (R&D) of Monitoring AI which Detects Acute Diseases

In addition to establishing an open platform on the infrastructure of community comprehensive care ICT ‘Team’ adopted by many medical institutions as well as nursing/long-term care facilities, and collecting data, in particular, from medical devices at home and facilities, it is aimed to conduct the research and development (R & D) of monitoring using AI analysis concerning the relationship with medical data such as test/inspection results.

● Development theme 3: Research and Development (R&D) of Telemedicine AI for Preventing and Screening the Increase in Severity of Chronic Diseases

With “Team” as an infrastructure, it is aimed to provide an interface for family members to input observation data, collect daily data, and secure data necessary for dementia treatment in relation to normal care, nursing, and medical practice, in addition to the research and development (R & D) of AI.

● Development theme 4: Research and Development (R&D) of Human Interaction AI in Interprofessional Collaboration

It is aimed to conduct the research and development (R & D) of caregiver support AI by means of human interaction AI through linkage among detection of errors from AI analysis of sent-off data (detection of errors in care as well as overlooked signs of an increase in seriousness, and sent-out contents related to infection, and so on), detection of symptoms/signs of increased seriousness of acute disease from vitals using monitoring AI described in development theme 2, and telemedicine AI for preventing and screening the increase in severity of dementia as described in development theme 3.

● Development theme 5: Research and Development (R&D) of Interaction-Based Indicator Analysis Platform

Establish an analysis platform for the causal relationship of interaction-based indicators, medical science-based indicators, and economics-based indicators in development

themes 1 to 4.

[3] (1-4)-(iii)Development of a system for the optimization of long-term care tasks and improvement of care quality based on excrement information

Head of research and development (R&D): Yoshimi Wie (Founder and CEO, aba Inc.)

Participating organization: aba Inc.

Many providers of long-term care services start working before obtaining sufficient specialized knowledge about long-term care, but the quality of lives of those who require long-term care is improved if care is carried out in an appropriate and timely manner. If the person requiring long-term care is in good condition, the burden on the caregiver is reduced, leading to a virtuous circle for both. This project intends to develop a long-term caregiver support system with which appropriate care can be provided even by a person without long-term care qualification and experience. For this long-term caregiver support system, we will establish a system based on excrement sensors that can obtain the excrement information which we believe is extremely important for long-term care services. Excrement information that is automatically obtained by excrement sensors will be linked to dietary records and medication information in order to improve the each service. In addition, we will achieve a more profitable way in using the current available information regarding long-term care and will establish a supporting system for those without long-term care experience to achieve a sophisticated long-term care services.

[Goals for this fiscal year]

For all of the development themes regarding 1 to 3, first we will conduct on-site surveys. Specifically, on-site analyses of the services will be conducted at multiple long-term care facilities (ten facilities or more). We will try not to choose the similar facilities, differing from scale and management policies. In addition, during this investigation, the sensors (such as positional information acquiring sensors and cameras) and other devices to be used in this outsourced project will be selected. During the process of this project from the last fiscal year, we will organize the intellectual properties regards to the long-term caregiver support system designed by aba Inc. and will consider the filing of conceptual patent applications.

[Midterm goals] (As of the end of FY2020)

Development theme 1: Collecting information on the excrements of at least 15 patients using excrement sensors. We will compare it with the food and drink

ingestion records held by the long-term care facilities in order to establish a method to deduce the cause-and-effect relationship. We will then verify at the clinical sites the appropriateness and profitability of the developed deduction method.

Development theme 2: Collecting information on the excrements of at least 15 subjects using excrement sensors. We will compare it with the positional information collected using RFID and other devices that will be installed within the facilities in order to establish a method to deduce the cause-and-effect relationship. We will then verify at the clinical sites the appropriateness and profitability of the developed deduction method.

Development theme 3: To acquire and analyze the information on caregivers' schedules and the relevant sensor information.

[Final goals] (As of the end of FY2022)

Development theme 1: To establish a system to deduce the cause-and-effect relationship between ingested ingredients and excrements. At least 30 subjects to be verified at the clinical sites.

Development theme 2: To establish a system to deduce the cause-and-effect relationship between excrements and behavior records. At least 30 subjects to be verified at the clinical sites.

Development theme 3: To automatically generate optimized schedules that additionally consider caregivers' schedules, and to verify them at the clinical sites. The goal is to increase the surplus time for caregivers by 10%.

- Development theme 1: To establish a system to deduce the cause-and-effect relationship between ingested ingredients and excrements
  I. To develop technologies for the simplification and automation of ingested ingredients recordings
  II. To establish a system to deduce the cause-and-effect relationship between ingested ingredients and excrements

- Development theme 2: To develop a system to deduce the cause-and-effect relationship between excrements and behavior records
  I. To develop technologies for the simplification and automation of behavior recordings
  II. To establish a system to deduce the cause-and-effect relationship between

behaviors and excrements

- Development theme 3: To optimize long-term care services in which caregivers' schedules are additionally considered
  I. To establish a system to analyze caregivers' schedules and optimize the schedules
  II. To develop a system to automatically generate optimized schedules

(2) Cross-Domain Data Exchange Platform Technology

Responsible sub-PD: Noboru Koshizuka

The objective of this topic is to establish a cross-cutting platform called *cross-domain data exchange platform (CDXP)* that will organize and link various data across multiple domains as well as mutually link the intra-domain data exchange platforms currently being constructed by individual ministries and agencies. Via CDXP, data scattered among the national and local governments and in the private sector can be organized and linked to treat them as Big Data for useful applications and services across multiple domains and organizations.

- To construct a platform that can be used by various companies and organizations to search and obtain data from various domains such as the private, academic and public sectors via API in a one-stop manner using data catalogs (metadata) and other methods.
- To arrange rules and frameworks with which utilization of CDXP is promoted. This is to be based on and consistent with the trends in overseas regarding the systems of data distribution and protection, and intellectual property strategies.
- To assure the cross-cutting data interoperability in collaboration with the ministries and agencies concerned that are arranging the core vocabularies common to various domains, the domain vocabularies unique to individual domains, the data structures, and so on, through the development of demonstration applications and arrangements of the necessary domain vocabularies.
- To develop CDXP (prototype version) by 2020 through agile-style development where trials and development activities are repeated, in parallel with the development of the demonstration applications. Following the verifications of the effectiveness in specific domains/areas, aim to construct a practical version of CDXP and to be prepared its social implementation by 2022.
- For the promotion of social implementation, to found a promoting organization (with the provisional name of Data.jp), playing an intermediary role for CDXP deployment,

and to promote popularization of the system (with the provisional name of Datahub) providing the tools necessary for data linkage to support the data alliance among companies in different domains.

- For international collaboration, to create a data distribution market by taking the leadership for data linkage in Asia. In addition, aim to enlarge the data distribution market to include Europe and the U.S. as well through de jure standardization (assumed in ISO).

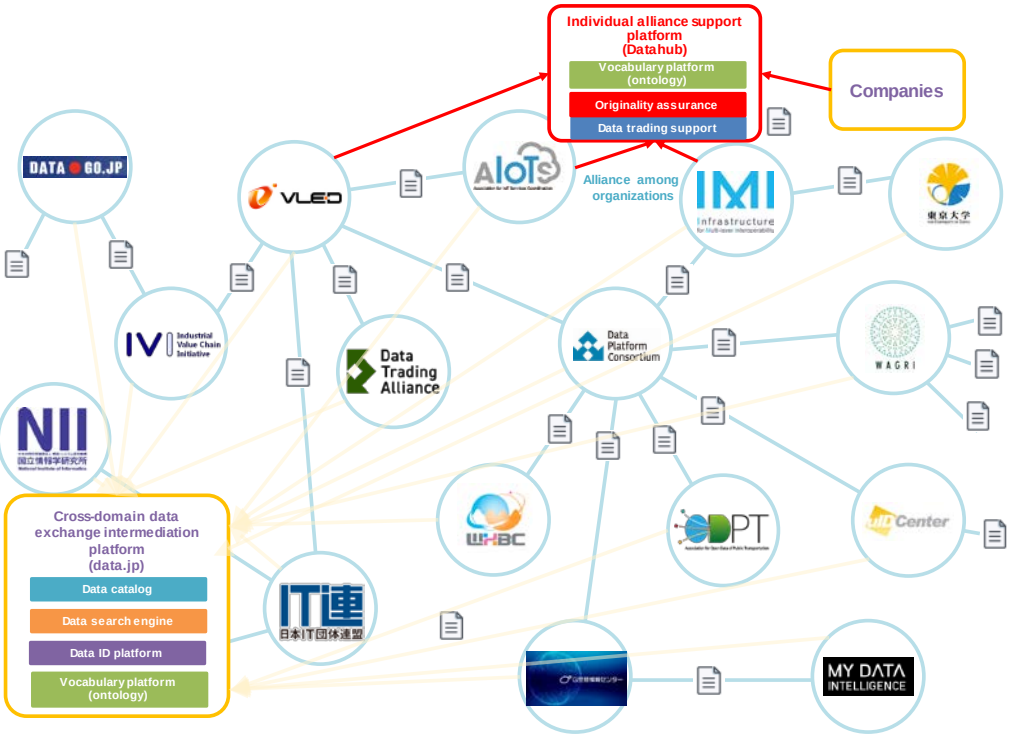

Figure 2-6. Overall image of CDXP

- **Final goal of research and development (R&D)**

To form an eco-system that can continuously and autonomously operate by CDXP that links the data scattered among the private, public, and academic sectors in order to supply big data usable as training data for AI.

- **Implementation method**

(i) Development of service platform technologies

- Overall design and development (data catalog management functions, search functions, common vocabulary and code management functions, authorization/approval functions, privacy consideration functions, community functions, and so on)
- Security functions (linkage with Cyber-Physical Security Infrastructure)

(ii) Development of service platform operation support technologies

- Semantically similar words prediction technology using AI
- Originality assurance technology
- Metadata creation support technology
- Wide-area expansion technologies for social implementation using Science Information NETwork (SINET), and others

(iii) Arrangement of rules and guidelines for service platform utilization

- Creation of specifications for data catalog, API and data quality criteria
- Provision of rules and guidelines for utilization of CDXP
- Studies on business models for CDXP

(iv) Effectiveness verification

- Verification of the functionality, performance, and operability of CDXP through development and demonstration of symbolic applications

(v) Social implementation

- Retainment of interoperability with the intra-domain data exchange platforms being arranged by the ministries and agencies, retainment of interoperability with Europe, the U.S and others, and promotion of international standardization
- Utilization of Big Data supplied by the CDXP for the creation of new values and new projects to solve various social issues
- Transfer of the CDXP operation to a private business operator

(vi) Demonstration applications

- For the Tokyo Olympic and Paralympic Games in 2020, development and verification of the service applications which collect and disseminate information of sightseeing, disaster evacuation and other related matters seamlessly for domestic and foreign athletes and visitors

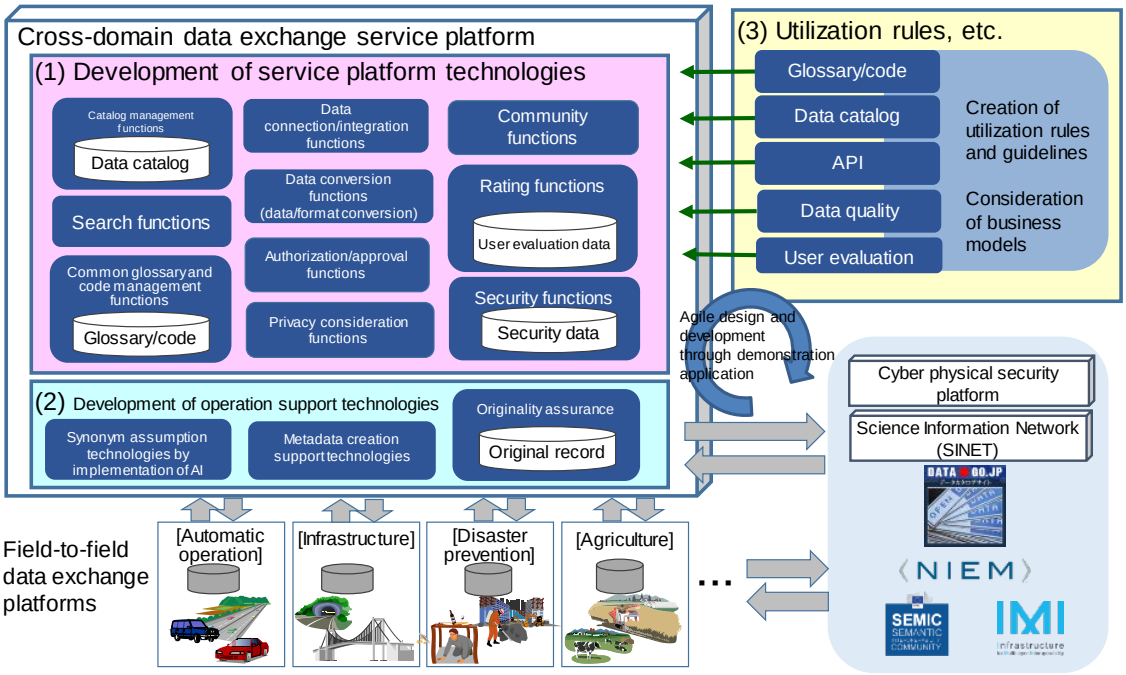

Figure 2-7. Overall image of CDXP

[1] (2)-(i) Research on a platform to realize data utilization and service provision of cross-domain and cross-organization

Head of research and development (R&D): Masazumi Hirono (Chief engineer, Hitachi Ltd.)

Participating organizations: Hitachi, Ltd., SB Technology Corp., University of Tokyo, NEC

Corporation, Fujistu Limited, (hereafter recommissioned) Info Lounge Corporation, University of Tokyo

For preparation of the intra-domain data exchange platforms that mutually links the cross-domain data exchange platform and other various data, we will research and develop the service platform technologies that easily realize linkage among data from multiple domains in a reliable and safe manner; will create criteria, guidelines, and so on, of data catalogs, APIs, data quality in order to assure interoperability; and will verify the effectiveness. Meanwhile, we will consider business models and carry out dissemination activities.

[Goals for this fiscal year]

Development theme 1: To revise the overall plan based on the investigation into the cross-domain data exchange platform (11 fields described in the Application Guideline

for "*Cross-ministerial Strategic Innovation Promotion Program (SIP) Period 2: Big-data and AI-enabled Cyberspace technologies*") and the like, and based on the review of the exit strategy. To perform the research and development (R&D) and verification of the technologies required for the service platform (vocabulary/code conversion technologies, and so on)

Development theme 2: To perform the research and development (R&D) and verification of the technologies used to support the service platform operation (data catalog creation support technologies, and so on)

Development theme 3: To create a data catalog for PoC, establish standard rules for the cross-domain data exchange, consider business models, and conduct surveys towards the foundation of a promoting organization to accelerate the social implementation of the cross-domain platform

Development theme 4: To perform PoC of the prototype data linkage platform. To complete development of sightseeing and disaster evacuation services for PoC

Development theme 5: To plan actions for international collaboration and standardization based on overseas market surveys

Development theme 6: Toward the establishment of an open-innovation-type framework for participation by user companies, to perform benchmarking of various domestic and foreign frameworks, and carry out dissemination activities using the selected method(s)

[Midterm goals] (as of the end of FY2020)
Development theme 1: To complete establishment of the service platform (prototype) that implements the intermediate products from the research of the technologies required for the service platform (vocabulary and code conversion technologies, and so on). To evaluate the research technologies through effectiveness verifications and to sort the results and countermeasures on a technology-by-technology basis

Development theme 2: To implement, on the service platform (prototype), the intermediate products from the research of the technologies to support the service platform operation (data catalog creation support technologies, and so on). To evaluate

the research technologies through effectiveness verifications and to sort the results and countermeasures on a technology-by-technology basis.

Development theme 3: Based on the result of verification of the effectiveness of the prototype data linkage platform, to propose revision of the standards and guidelines created by the standardization bodies. To consider the business models for the cross-domain data exchange platform (Data.jp + Datahub) and determine the management form. To complete the creation of training materials for dissemination

Development theme 4: To perform effectiveness verification of the prototype data linkage infrastructure by using the sightseeing application, sort the results of evaluation of the cross-domain data exchange platform, and feed them back to the individual teams of each theme

Development theme 5: To prepare a demonstration experiment based on the international collaboration scheme and to start activities for international standardization.

Development theme 6: To establish the prototype function and tool providing system (Datahub). To perform effectiveness verification for the evaluation of the tool providing system and sort the measures to be taken.

[Final goals] (as of the end of FY2022)
Development theme 1: To complete establishment of the service platform that implements the research of the technologies required for the service platform (vocabulary and code conversion technologies, and so on). For the service platform, to complete implementation of the results of effectiveness verification on the practical-version data linkage infrastructure

Development theme 2: To complete establishment of the service platform, which implements the result of the technology research to support the service platform operation (data catalog creation support technologies, and so on). For the technology research, to complete implementation of the results of effectiveness verification on the practical-version data linkage infrastructure

Development theme 3: To revise the criteria and guidelines that are based on the

results of the effectiveness verification on the practical-version data linkage infrastructure. To found a management organization for the cross-domain data exchange platform (Data.jp + Datahub). To conduct training toward dissemination

Development theme 4: To perform effectiveness verification by utilizing the applications for effectiveness verification on the practical-version data linkage infrastructure, sort the results of the evaluation, and feed them back to the individual development themes. To improve the application development efficiency by at least 20% by utilizing the cross-domain data exchange platform.

Development theme 5: To carry out a demonstration experiment based on the international collaboration scheme and realize (part of) the standardization deliverables through the activities of international standardization.

Development theme 6: To complete establishment of the practical-version function and tool providing system (Datahub). To continue operating the open-innovation-type framework for participation by user companies in order to increase the number of *data providers* and *data users* of the cross-domain data exchange platform.

Development theme 1: To develop service platform technologies

I. To investigate the requirements for and overall planning of the cross-domain data exchange platform (Holder: Hitachi)
Review of the requirements for the cross-domain data exchange service platform
Overall plan of the cross-domain data exchange platform

II. To research technologies for the cross-domain data exchange service platform
Rating technologies for the evaluation of data quality (Holder: Hitachi)
Technologies of advanced search and recommendations to facilitate cross-cutting data searches (Holder: Fujitsu)
Vocabulary and code conversion technologies to foster the mutual operation of data from different domains (Holder: Hitachi)
Common API linkage technologies based on international standards (Holder: NEC)

III. To establish the service platform (Holder: Hitachi)
Establishment of the service platform for the effectiveness verification on the prototype

data linkage infrastructure

Establishment of the service platform for the effectiveness verification on the practical version data linkage infrastructure

Development theme 2: To develop service platform operation support technologies

I. Synonym assumption technologies for assumption and conversion of the vocabulary differences (Holder: Fujitsu)

II. Data catalog creation support technologies to promote data utilization (Holder: Hitachi)

III. Data originality assurance technologies using the distributed ledger technologies, and so on (Holder: Fujitsu)

IV. Technologies for linkage with the Science Information NETwork (SINET) under assumption of utilization as the testbed (Holder: University of Tokyo)

Development theme 3: To arrange rules, and so on, for utilization of service platform (Holder: Hitachi)

I. To consider the specifications for data catalog, API and data quality criteria

II. To create the rules and guidelines for utilization of the cross-domain data exchange platform

III. To consider the business models for the cross-domain data exchange platform and found the operating body

IV. To act to disseminate the cross-domain data exchange platform, training, and so on.

Development theme 4: To verify the effectiveness of the cross-domain data exchange platform by application development

I. To develop and demonstrate the prototype data linkage infrastructure (Holder: SB Technology)

II. To develop and demonstrate the practical-version data linkage infrastructure (Holder: Hitachi)

Development theme 5: Efforts toward realization of international collaboration (Holder:

Hitachi)
I. To investigate the data distribution and utilization business mainly focusing on Asia (three-pole models, support tools, and so on)

II. To promote international standardization such as ISO (common standards, and so on, for data distribution, AI utilization guidelines, and the like) and IEEE (data structures, and so on)

III. To demonstrate the interoperability of the infrastructures for data distribution among countries, and so on, based on the international standardization plan

Development theme 6: To establish an open-innovation-type framework (Holder: Hitachi)
I. To act on dissemination toward promotion of cross-domain use of data, and so on

II. To establish the function and tool providing system (Datahub)
Development and demonstration of the prototype function and tool providing system
Development and demonstration of the practical-version function and tool providing system

[2] (2)-(ii) Research and Development of Cross-Domain Data Exchange Platform Technology centered on Metadata Structuring applying AI Technology and their Demonstration using Spatio-temporal Big Data Applications

Principal Investigator: Atsuhiro Takasu (Professor, National Institute of Informatics (NII))
Participating Organizations: National Institute of Informatics (NII), NTT DATA Corporation, JIP Techno Science Corporation

This research aims to develop core technologies for sharing and linking data from various domains. Technology for structuring metadata using AI will promote linking various data from different domains. To prove its effectiveness, we are going to check the functions using spatio-temporal Big Data applications.

[Goals for this fiscal year]
Development theme 1: To clarify the specifications of each function that should be employed for the cross-domain data exchange platform (CDXP). To complete high-

level design of the CDXP components that will be actively used in the demonstration with prototype applications.

Development theme 2: To clarify the technical functions required for data search, data linkage, and data registration support. To implement the functions common to the CDXP operation support such as technology for semantically similar terms prediction, and the mapping data items of metadata.

Development theme 3: To complete basic investigation in pursuit of a sustainable business model and measures for service spread of the platform. To complete the investigation toward founding a promoting organization for acceleration of societal implementation of the CDXP.

Development theme 4: Using the prototype application for limited users, to have the evaluation and recognition of the effectiveness of the data linkage service.

Development theme 5: By making efforts for international linkage of the common vocabulary framework in a specific domain, to establish a fundamental framework for international collaborations.

Development theme 6: To implement demonstration applications used for use-case arrangements for promoting conception of new services. To add scalability for the demonstration application developed in the theme 4 so that it can be applied in larger regions.

[Midterm goals] (as of the end of FY2020)

Development theme1: To implement the part to be used for the prototype application and to work with the application. To create a concrete plan toward commercialization.

Development theme 2: To implement the part of the data search, data linkage, and data registration support technologies that is to be utilized in the prototype application.

Development theme 3: To create a business model idea of CDXP; try the operating organization, the dissemination activities, and the training activities; and create an action plan when the practical deployment starts.

Development theme 4: By using the application for demonstration that is available to general users, to evaluate and recognize the effectiveness of the data linkage service.

Development theme 5: To develop and make available the functions for common vocabulary framework required for international data linkage as well as cross-domain data exchange.

Development theme 6: To conduct a demonstration experiment using a service application with nationwide contents as part of use case arrangements for promoting

conception of new services,

[Final goals] (as of the end of FY2022)

Development theme 1: To implement the functions that should be employed for the service platform CDXP, and link them with multiple intra-domain data exchange platforms. To have a commercialized product that incorporates the developed technology.

Development theme 2: To implement the service platform operation support functions to which the data search, data linkage, and data registration support technologies are applied, and to verify their effectiveness.

Development theme 3: To prepare the operating body of CDXP ready for operation, and to clarify the concrete plan and framework for seamless support of its service expansion, training, and other related activities.

Development theme 4: By practical applications available to general users and business users, to actually provide the data exchange and linkage services, and to evaluate and recognize the effectiveness of the platform.

Development theme 5: To make efforts for international linkage of the common vocabulary framework in specific domains and evaluate its effectiveness through prototyping of applications, and at the same time to establish guidelines for international expansion of the common vocabulary framework in multiple domains.

Development theme 6: To accomplish arrangements for promoting conception of new services through application service demonstrations with nationwide contents.

- Development theme 1: Development of Service Platform Technology

I. Design and development of functions including the data catalog management functions, the search functions, and the common vocabulary and common code management functions.

II. Execution and evaluation of the platform technology using prototype and practical-version applications.

- Development theme 2: Development of Service Platform Operation Support Technology

I. Technology for semantically similar terms prediction applying AI

II. Technology for data construction and metadata creation support

- Development theme 3: Rules and Guidelines for Service Platform Operation

I. Studies of business models for the service platform CDXP

II. Preparatory actions for spreading CDXP utilization including training.

III. Preparations for founding a promoting organization in pursuit of accelerating societal implementation of CDXP.

- Development theme 4: Verification of the Effectiveness of CDXP through Application Development and Usage

I. Development and demonstration of the prototype CDXP with prototype applications

II. Development and demonstration of the practical-version CDXP with practical applications

- Development theme 5: Realization of International Collaboration in Data Sharing and Linkage

I. Establishment of the framework for international collaboration.

II. Construction and demonstration of the common vocabulary framework and the linkage functions across the multiple domains.

- Development theme 6: Construction of an Open-innovation-type Framework for Corporate User Participation

I. Arrangement of use cases contribute to promoting conception of the new services

(3) AI based automatic negotiation platform technology

Responsible sub-PD: Takashi Washio

To realize an AI based automatic negotiation platform used by each of those AI that are managing and controlling the individual services not necessarily having common interests due to independent operation by different organizations, in order to cooperate and link with the other AI.

- Standardization of protocols, vocabulary definitions, and the like necessary for the interconnectivity and interoperability with which various AI collaborate with each other in various manners in the real world
- Establishment of an adjustment basis for collaboration between AI that sufficiently answers issues such as communications, throughput, and security
- Establishiment of an algorithm (adjustment principle) for collaboration between AI in the real world
- Design of detailed rules necessary for each use case and creation of social receptivity
- Development of a reference architecture with regard to the adjustment basis/principle/system based on the commonality and individuality of the use cases
- In order to promote social implementation, verification of the technologies and values of provision while conducting in parallel prototype development and a demonstration experiment with the user companies involved in fields with strong societal demand. Specifically, the target is to improve productivity in the manufacturing industry, which

is one of Japan's strong points, and solve the social issue of manpower shortage so as to contribute to economic development. Another target is to solve the social issues in the health, medical care and long-term care fields due to a declining birthrate and an aging population. By conducting a demonstration experiment, to clarify the effect of introduction as soon as possible in order to acquire early-adoption users

- Standardization and disclosure of the API/data models among the collaborative AI and between the collaborative AI and the individual AI, which are related to the interoperability, and promotion of dissemination in collaboration with international consortiums, industry groups, standardization groups, academic communities, and others

• **Final goal of research and development (R&D)**

The goal is to form more efficient controls and new win-win opportunities through cooperation and collaboration among multiple AI in the world where various systems are controlled by AI.

• **Method of execution**

(i) Creation of various protocols, and so on

Creation of communications protocols, vocabulary definitions, and so on, for collaboration among AI

(ii) Designing of reference architecture

Not to design and implement every use case from the beginning, but to develop a reference architecture regarding the adjustment basis/principle/system that recognizes the commonality and individuality among the use cases and is required for social implementation in a systematic and efficient manner

(iii) Development of adjustment basis

Development of a basis for the safe, fair, and efficient realization of the AI based automatic negotiation through message management, operation of various databases, and so on. To include functions for the timely detection of an inappropriate arrangement action and for detailed ex-post facto analyses

(iv) Development of adjustment principle

Establishment of the basic method of automatic collaboration by using standardized protocols and vocabulary definitions, and a demonstration experiment in which

integration of the below-mentioned business systems is included

(v) Development of technologies for integration with business systems

Development of technologies used to integrate the operations of business systems including the internal management and system control systems that constitute the above-mentioned basic method of collaboration and each use case. To integrate the AI based automatic negotiation and the planning business systems in order to improve the efficiency of each of the actual business tasks

(vi) Establishment of adjustment system

Development of rules for AI based automatic negotiation, aiming for balance between improvement of the usefulness of the individual systems and improvement of the social usefulness. To include a definition of prohibited items. To implement these on the above-mentioned adjustment basis

(vii) Actions for international collaboration and standardization in order to internationally develop adjustment principle and adjustment systems

Performance of the standardization and international collaboration required to reduce the country-by-country responding cost and globally operate the AI based automatic negotiation

(viii) Demonstration of use cases

By establishing an AI-related negotiation platform and selecting use cases, to clarify the specifications specific to each of the use cases and the problems in social implementation, and then confirm the operation on the basis of simulation of the infrastructure. By using the data obtained from multiple participating companies and organizations, to build a model and review the simulation base so that the use cases can clearly express the real-world articles. On site, to additionally verify the effects, and so on, of the improvement by the operation integration with the business systems and the AI based automatic negotiation

[1] (3)-(i) Improvement of efficiency and flexibility of value chain through inter-AI cooperation

Head of research and development (R&D): Satoshi Morinaga (NEC Corporation)

Participating organizations: NEC Corporation, Oki Electric Industry Co., Ltd., Toyota Tsusho Corporation, Tokyo University of Agriculture and Technology, University of

Tokyo, (hereafter recommissioned) Chuo University, University of Tokyo, Nagoya Institute of Technology, National Institute of Advanced Industrial Science and Technology

The objective of this research and development (R&D) is to develop AI based automatic negotiation platform technology used to support and automate the adjustment of the terms and conditions of commercial transactions between ordering and accepting companies. To actually improve the efficiency and the flexibility of the value chains of manufacturing and physical distribution by making it easier to find “win-win” terms and conditions for both the ordering party and the accepting party, in order to help raise Japan’s industrial competitiveness. Specifically:

- To design a reference architecture in which multiple use cases are considered
- To develop a principle that enables adjustment in a simultaneous and parallel manner and adjustment in a dynamic environment
- To establish various protocols required for interoperability among companies and among internal systems
- To develop technologies for integration with the business systems used to extract and create information necessary for adjustment
- To develop a platform to provide a place for safe, reliable, efficient, and fair adjustment
- To establish an adjustment system for mapping with the appropriate commercial transactions in the real world
- To act for international collaboration and standardization to internationally develop the adjustment principle and the adjustment system
- To define and select appropriate application use cases

In addition to the above, the objective includes prototype demonstration by integration.

[Goals for this fiscal year]

- To combine the negotiation platform, negotiation AI, and business systems with the manufacturing lines and means of transport on the simulator for the purpose of demonstration of the negotiation actions
- To approve the official test bed at international consortiums and to hold relevant competitions at international meetings
- Through exchanges of opinions with experts and actual workers in the business fields

concerned, to refine the solution specifications and the detailed architecture design to a level at which the demonstration experiment planned in the next fiscal year may be carried out

[Midterm goals] (as of the end of FY2020)

- To actualize the following specifications regarding the target use cases in parallel, robust, and dynamic negotiations:
  - In the manufacturing use case, to complete, in the order of minutes, a negotiation regarding the terms and conditions of product trade between one company and five companies or so. In addition, to realize a demonstration of a 1-to-1 negotiation including an actual plant
  - In the physical distribution use case, to complete, in the order of minutes, a negotiation regarding an adjustment of transportation frameworks between three companies and two companies or so

[Final goals] (as of the end of FY2022)

- To confirm the conclusion of commercial transactions by performing demonstrations concerning the target use cases with the cooperative companies. In the manufacturing use case, by establishing an experimental market containing five or more company participants, to verify that adjustment of ordering and order accepting among 10 or more companies including virtual companies can be realized in the order of minutes. In the physical distribution use case, to verify that a negotiation regarding an adjustment of transportation frameworks can be carried out in the order of minutes between three company participants and two or so.
- To assess the impacts on market stability and efficiency by predefined malicious acts and anomalies in a market in which multiple negotiating parties are participating.
- To standardize forums by utilizing international consortiums.

• Development theme 1: Parallel negotiation

To propose a protocol for negotiations between two parties by reviewing actual manufacturing use cases, and so on

• Development theme 2: Dynamic and robust negotiations

(1) Robust and automatic negotiations: To establish a method to go on with negotiations in a safe and secure manner by clarifying the uncertainty of the future utility function and then considering it, and a method to predict the utility function by using the input and

output history of the agent on the other party's side: (2) Dynamic and automatic negotiations: To establish a method for negotiations in a case where the utility function dynamically changes as the time for the negotiation process passes

- Development theme 3: Negotiation platform

  Based on the common and basic part separately researched and developed by the researchers, to search and develop the part dependent on the use cases, and research and develop a negotiation platform for the manufacturing and physical distribution fields that provides security, ease to develop, affinity with existent IT systems, functional extensibility, and scalability

- Development theme 4: Integration of manufacturing business systems and demonstration of use cases

  To perform simulation evaluation and on-site verification through use case targeting and clarification of the problems concerning specific specifications and social implementation

- Development theme 5: Integration of physical distribution systems and demonstration of use cases

  To carry out use case targeting and clarify problems concerning specific specifications and social implementation

- Development theme 6: Reference architecture

  To design a reference architecture by actualizing the manufacturing and physical distribution use cases and then determining their commonality and individuality

- Development theme 7: Activities for international collaboration and standardization

  To establish a link with the ecosystem of the other party by adding the functions for adjustment of commercial transaction terms and conditions to the Smart Factory Web, which is currently standardized by the Fraunhofer Society in Germany

- Development theme 8: Adjustment system

  To research and develop some business, social, and legal rules aiming for balance between improvement of the usefulness of the individual systems and improvement of the social usefulness

- Development theme 9: Marketplace stability and safety

To assess the impacts on the market by malicious acts and anomalies in the assumed use case through analyses using simplified models based on system engineering and others, and through analyses using agent simulations

• Development theme 10: Development of a re-adjustment/re-negotiation model through information sharing

To consider a system for the sharing of part of information on the ordering party's requirements and the accepting party's resources on the marketplace with the promoter (or a reliable intermediary agent)

[2] (3)-(ii) Establishment of Collaborative Framework and a corresponding AI technology platform for health, medical care and long-term care

Head of research and development (R&D): Naohisa Yahagi (Associate Professor, Keio University)

Participating organizations: Keio Research Institute at SFC, Institute of Physical and Chemical Research, National Center for Child Health and Development, Saga University

In order to achieve both reductions of social costs and maximization of the QOL of individuals, the government is reviewing the information infrastructure that links the individual fields for health, medical care and long-term care services. Based on the aforesaid political direction, through this research and development (R&D) project, we will establish a Collaborative Cognition Framework and a corresponding AI technology platform (as 'AI collaborative platform' for short) where standardization and interconnections are enabled, and cooperation and competition are both possible so that the individual AI in the fields concerned can be linked and interlocked for support of the individuals, and will perform verification by using use cases.

The operating body of the AI collaborative platform is required to establish the information infrastructure that is being promoted in the health, medical care and long-term care fields, and in addition, is required to be established as a public institution that supports the society. Therefore, the operating body must be determined based on consultations with the government ministries and agencies concerned and must establish a sustainable operating scheme. The goals are realization of extension of healthy life expectancy in Japan and development of a package to help develop it in Japan and spread it to foreign countries by standardizing that platform and the protocols.

[Goals for this fiscal year]

- To create a reference architecture extension design
- To assume a case where multiple system services and AI services are provided to the individuals in the health, medical care and long-term care fields, to confirm the information distribution, and to investigate the adaptation effects
- To define the health indices on the coordination basis and to consider the linkage environment including solving problems and investigating how to improve the functionality

[Midterm goals] (as of the end of FY2020)

- To investigate and verify communications protocols, standard vocabulary infrastructures, reference architectures, health indices, and methods of automatic collaborations between AIs
- To review the authentication system and to create draft documents of the reference architecture and standardization protocols, and so on

[Final goals] (as of the end of FY2022)

- To allow medical institutions and long-term care service business operators to connect to the AI collaborative platform, by which they can a) efficiently operate their own organizations, b) reduce the burdens of workers, and 3) improve the QOL of patients/care receivers

- Development theme 1: Formulation of various protocols

Based on the review status in the past at JAHIS and others, the vocabulary linkage considered at the time of establishment of the CDMS, and verification of the standard vocabulary infrastructure and others by IPA, to create a standard communications protocol and a vocabulary infrastructure enabling close and real-time collaboration between AI in each of the health, medical care and long-term care fields (hereinafter, “each field”)

- Development theme 2: Design of reference architecture

By employing as a model the CDMS so far reviewed by the AMED, and by assuming a case where collaboration is established between the health consultation AIs working for the individuals and the medical institutions, to consider a medical model case of the reference architecture required for collaboration among the AI in the health, medical care and long-term care fields and, systematic and efficient social implementation

- Development theme 3: Development of basic coordination infrastructure

Based on the experience of developing the Agriculture Data Collaboration Platform, to develop and implement a cloud infrastructure that provides functions such as access log management, audit trial storage, and real-time monitoring of behaviors of each AI, aiming at realization of a safe, fair, and highly efficient AI collaborations in the health, medical care, long-term care, and daily life fields

- Development theme 4: Development of coordination architecture

To set, on the reference architecture, those (multidimensional) health indices that are used as the evaluation criteria and performance indicators for each of the connected AI, aiming at establishment of the basic methods of the structuration data distribution and of the automatic collaboration between AI

- Development theme 5: Prototyping of Integrated technology development with business system

Based on the linkage among different systems built for establishment of the Agriculture Data Collaboration Platform, to investigate and review the functions regarding appropriate collaboration and integration of the data and behaviors among the individual AI connected to the AI collaborative platform with regard to part of the physical distribution of the pharmaceutical products in the emergency use case, selected from the business systems in each of the electronic health record, receipt, long-term care receipt, personnel and human resource management, and other fields.

- Development theme 6: Use Case Demonstration

To investigate and verify the reference model that uses AI collaborative platform as a use case regarding the physical distribution of pharmaceutical products starting from triage connected to the AI collaborative platform in the emergency medical care services led by Saga University.

- Development theme 7: Formulation of an adjustment system

Based on the development of the adjustment principle, to review the application of the coordination system in order to design the rules for collaboration between AI aiming at high-level balancing between the improvement of operability of each connected AI and the social usefulness ((i) efficient operation by business operators, and so on (ii) reduction of workers' burdens, and (iii) improvement of QOL of patients and long-term

care receivers).

- Development theme 8: To carry out international collaboration and standardization activities toward international development of the coordination principle and the adjustment system

To conduct investigations toward the arrangement of reference models, health indices, standardization protocols, and the like, and to make preparations for international distribution so that the developed AI collaborative platform becomes acceptable also in overseas countries and can be internationally developed.

(4) Architecture development

In order to realize Society 5.0, the architectures which will make mutual linkage easier among domains and companies will be developed by public-private partnership regime in the domains of the smart city and the personal data while both promoting verification projects utilizing AIs, big data and so on and collaborating the cross-domain data exchange platform project.

- To collect and analyze the information on domestic and foreign architectures and use cases in the domains of the smart cities and the personal data
- To sort the components of the domestic and foreign concrete use cases on various fields into the layers of the Society 5.0 reference architecture (strategy/policy, rule, organization, business, data, cross data exchange, and asset) (Figure 2-8)
- To develop the architecture both while conducting multiple verification projects which are selected as use cases to be demonstrated and while building consensus among stakeholders
- To promote cross data exchange among domains and companies, arrangement of systems, international standardization and so on by sharing the architecture among stakeholders,

• Final goals of research and development (R&D)

To develop an architecture that will help promote city OS designing, international standardization, cross data exchange among domains and companies, and so on, both through arranging and structuring the domestic and foreign related projects in the domains of the smart city and the personal data and through verification projects. Based on the architecture and based on common views and understanding between the public and private sectors, to accelerate technical development, social implementation, cross data exchange,

international standardization, system arrangement, and so on, to accelerate realization of smart cities, and to accelerate exchanging and trading personal data smoothly.

• **Method of execution**

(i) Investigation and analyses in each field

- Investigation and analyses of trends of domestic and foreign reference architectures, international standardization, and so on
- Investigation and analyses of domestic and foreign use cases in each field
- Analyses of components of each use case (functions, data, data linkage, asset, business, organization, rule, strategy/policy) and sorting of relationships
- Sorting of related standards, and so on, regarding each component

(ii) Use case verification project

- Selecting the use cases that should be demonstrated and clarifying the demonstration objectives
- Individual architecture designing
- Evaluation and review of deficiency and excess in each component
- Reflection of the knowledge obtained through verification projects to the architecture and verification of the architecture

(iii) Developing an architecture for each field

- Arranging relationships among components of multiple use cases (linkage, commonization, and so on)
- Setting the cooperative domain and reviewing the international standardization strategy, system design, and so on
- Developing an architecture for each field

(iv) Dissemination, sustained promotion, and so on, of architectures

- Activities for architecture dissemination in parties concerned
- Considering establishment of an organization responsible for continuous addition and update of the architectures

(v) Cross-domain architectures exchange

- Cross-domain architectures exchange including geography-related architectures

[Goals for this fiscal year]

- To develop architectures in the domains of smart cities and personal data
- To conduct related verification projects that help develop architectures in the domains of smart cities and personal data
- To consider and establish an organization responsible for sustained update, dissemination, and so on, of architectures in the domains of smart cities and personal data
- To implement cross-domain architectures exchange

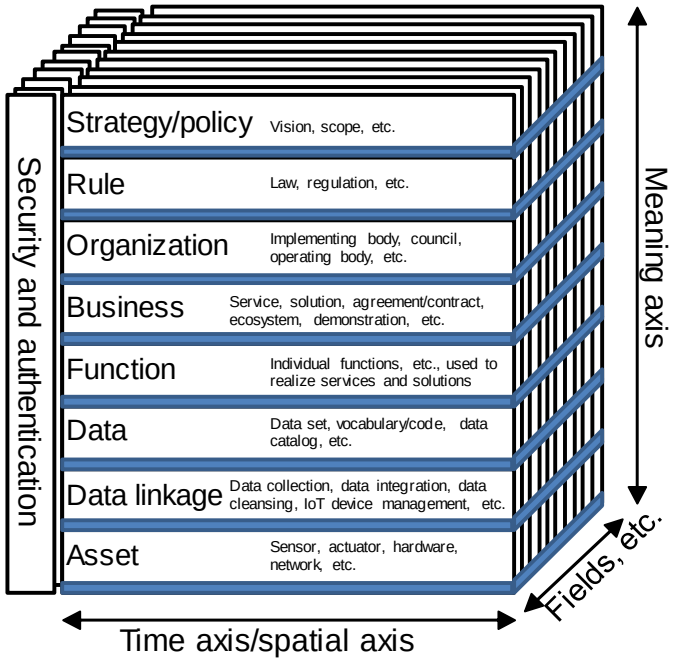

Figure 2-8. Society 5.0 reference architecture

3. Implementation System

(1) Utilization of National Research and Development Agency New Energy and Industrial Technology Development Organization (NEDO)

This program utilizes the grants to NEDO to implement the structure shown in Chart 3-1. The PD is responsible for formulating and promoting research and development plans. The PD chairs the committee, and the Cabinet Office serves as its secretariat. The committee consists of relevant ministries and agencies, experts and intellectuals. NEDO, a national research and development corporation, will be utilized to promote research and development by a research director selected from among applicants. NEDO manages the progress of each research topic. The PD shall be assigned a sub-PD as necessary to assist the PD in managing the content and progress of research

and development.

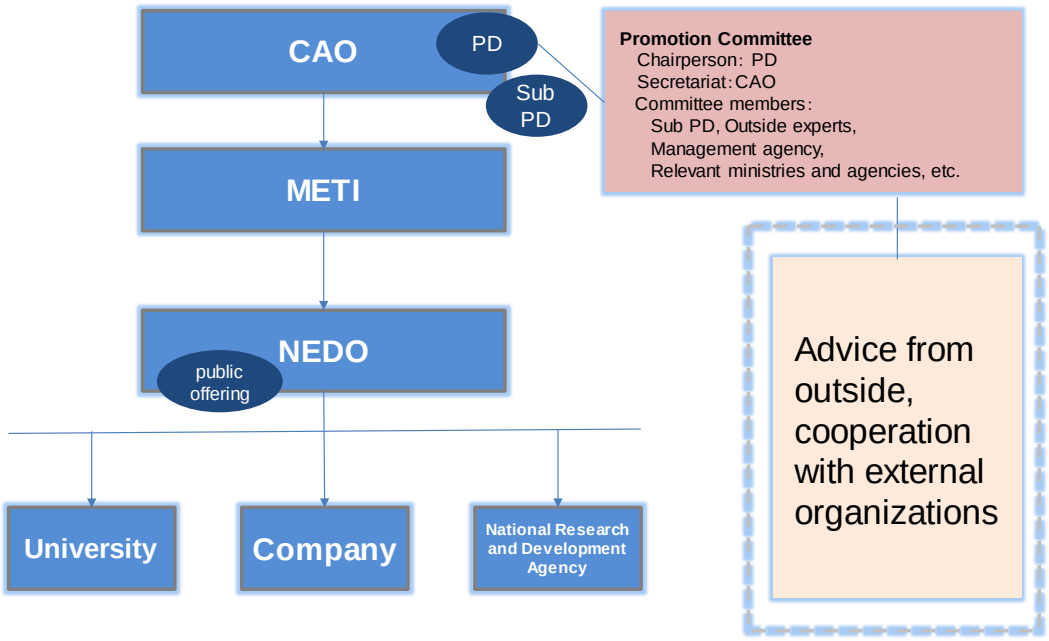

Figure 3-1 Implementation Structure

Research and development with an eye toward the exit by cooperation of PD/sub-PDs/strategies coordinator (Strategies C) is promoted by placing Masaaki Mochimaru (in charge of human interaction platform technology), Noboru Koshizuka (in charge of cross-domain data exchange platform technology), and Takashi Washio (in charge of AI-based automatic negotiation platform technology) as the sub-PDs, and by placing Takayoshi Kawakami (organizer of exit strategy) as the Strategies C.

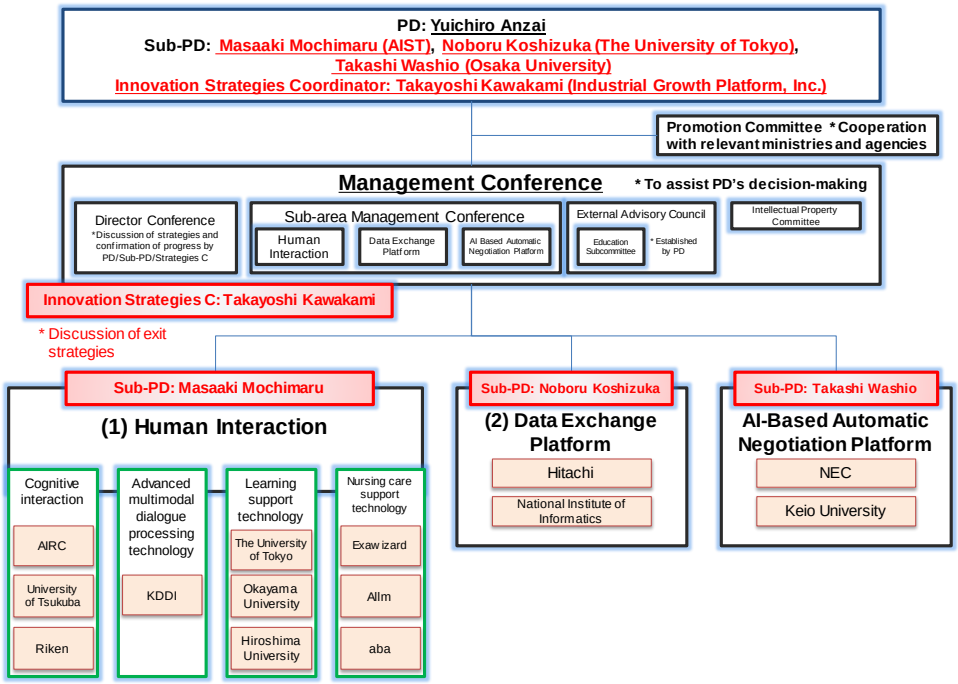

Figure 3-2 Management Structure

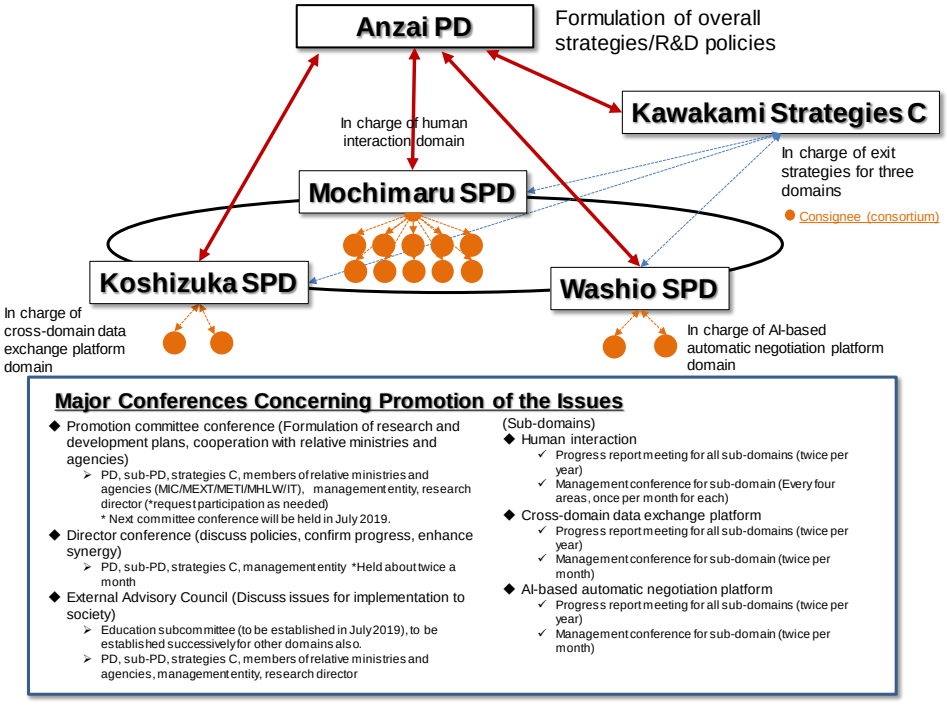

Figure 3-3 Project Management Structure

(2) Selection of Research Director

NEDO selects the research director through public offerings, based on this program. The process of screening for this selection, including its criteria and judges, shall be

decided in consultation with the PD and the Cabinet Office. In general, the PD and the Cabinet Office staff shall take part in the screening. People relevant to researchers who apply themes in the application must not take part in the judgment of the themes. The definition of the relevant people will be determined by NEDO. After the themes of the research are decided through the screening, the title of the themes and the names of the research directors and the parties of the research participants are added to this plan.

(3) An Attempt to Optimize Research Structure

The PD may change and add research themes depending on the progress, the results of technical studies, etc. performed by the relevant organizations, or changes in social conditions.

Also, this project may adopt for some research themes the stage-gate system in which will narrow down the research entities a certain period after selecting and promoting a variety of ideas, in order to promote this project under the optimal structure.

(4) Advice from Outside and a Scheme to Cooperate with External Organizations

By setting WGs that correspond to the main research themes under the promotion committee, obtain advice from domestic and foreign intellectuals, and at the same time attempt close cooperation with the existing relevant organizations and activities.

(5) Cooperation with Ministries and Agencies

With the Cabinet Office as the base, social implementations will be accelerated by utilizing each element technology and research result proven by the respective government office/organization (AI3 center[9], etc.); by conducting demonstration experiments at the sites that are optimal for each government office; and by extracting the validity and the systems that may become an issue.

(6) Contribution from Industry

Contribution (including human resources or material) of about 20 to 30% of the total research and development amount (total of both national expense and contribution from industry) is expected from industry from now on.

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[9] The Center for Information and Neural Networks (CiNet) and the Universal Communication Research Institute (UCRI) of the NICT, the RIKEN Center for Advanced Intelligence Project (AIP), the Artificial Intelligence Research Center (AIRC) of the National Institute of Advanced Industrial Science and Technology.

4. On Intellectual Properties

(1) Intellectual Property Committee

- For each project, or each research item that makes up the project, establish an Intellectual Property Committee in the management entity or the organization to which the selected research director (consignee) belongs.
- The Intellectual Property Committee decides on the policies by which to publish theses on the research and development results of the organization that established the committee, and applies for and maintains the patents (hereinafter referred to as the "intellectual property rights"). Also, it makes adjustments for the licensing of the intellectual property rights as needed.
- In general, the Intellectual Property Committee consists of the PD or representatives of the PD, major related parties, experts, and so on.
- The details of how to operate the Intellectual Property Committee are determined by the organization that established the committee.

(2) Agreement for Intellectual Properties

- The management entities shall determine in advance through the contract with the consignee on how to deal with confidentiality, the background intellectual property rights (the rights acquired by the research director, or the organization to which he/she belongs, which were held before participating in the program, and the rights acquired after participating in the program without using the project funds of the SIP), and the foreground intellectual property rights (the rights that arose using the project funds of the SIP in the program).

(3) Licensing of Background Intellectual Property Rights

- The licensing of background intellectual property rights to the participants of other programs may be approved by the intellectual property rights holder, according to conditions determined by the holder (or with agreement among the participants).

- If there is a risk that these conditions and other responses of the intellectual property right holder may cause problem with the promotion of the SIP (not only in the research and development but also in the practical application/industrialization of the results), then make adjustment in the Intellectual Property Committee, and get a reasonable solution.

(4) Dealing with Foreground Intellectual Property Rights

- The foreground intellectual property rights will belong to the organization (consignee) to which the research director or the inventor belongs, in general, by applying Article 19, paragraph (1) of the Industrial Technology Enhancement Act.
- When the inventor is the subcontractor or other party and when the intellectual property rights belong to them, an approval of the Intellectual Property Committee is required to transfer the intellectual property right. The Intellectual Property Committee may attach conditions at this time.
- If the intellectual property right holder lacks the will to industrialize, then the Intellectual Property Committee recommends the possession and licensing of the intellectual property rights be granted to those willing to industrialize.
- For those who withdraw during participation, the management entities and other parties may have all or part of the results gained using the project funds of the SIP during participation (if the participation period extends for more than one fiscal year, then all of the results from the very beginning) transferred free of charge at the time of withdrawal and set its license.
- In general, expenses for patent application and maintenance shall be paid by the intellectual property right holders. In the case of joint application, the interest rate and burden of expenses shall be determined by and between the joint applicants.

(5) Licensing of Foreground Intellectual Property Rights

- The licensing of foreground intellectual property rights to the participants of other programs may be approved by the intellectual property rights holder, according to conditions determined by the holder (or with agreement among the participants).
- The licensing of foreground intellectual property rights to a third party may be approved by the intellectual property rights holder, according to conditions determined by the holder that are not advantageous over the program participants.
- If there is a risk that these conditions and other responses of the intellectual property right holder may cause problem with the promotion of the SIP (not only in the research and development but also in practical application/industrialization of the results), then make adjustment in the Intellectual Property Committee, and get a reasonable solution.

(6) Transfer of Intellectual Property Rights, or Approval for Granting/Transferring of Exclusive License

- Based on Article 19, paragraph (1), item (iv) of the Industrial Technology

Enhancement Act, the transfer of foreground intellectual property rights and the grant/transfer of exclusive licensing rights require the approval of the management entities, excluding cases such as transfer due to merger/division, or transfer of intellectual property right or grant/transfer of exclusive license to subsidiary companies/parent companies (hereinafter referred to as the "transfer of intellectual property rights due to mergers").

- For the transfer of intellectual property rights due to mergers, the intellectual property right holders shall require approval of the management entities based on the contract with the management entities.
- Even after the transfer of intellectual property rights due to mergers, the management entities may hold the license with the right to sub-license such intellectual property rights. If the conditions concerned are not acceptable, the transfer will be rejected.

(7) Dealing with Intellectual Property Rights upon Completion

- Upon completion of the research and development, the management entities shall discuss how to deal with the intellectual property rights that no applicant wants to hold (either to waive or to have the management entities succeed).

(8) Participation of Foreign Organizations (Companies/Universities/Researchers, etc.)

- Relevant foreign organizations may participate if it is necessary for promotion of the issue.
- From the viewpoint of appropriate execution and management, it should be the rule to have a contact person or an agent within the country who can handle the administrative work for the entrustment of research and development.
- For foreign organizations, the intellectual property rights shall be jointly owned by the management entities and external organizations.

5. On Evaluation

(1) Evaluation Entities

The external experts whom the governing board based will invite on the Operational Guidelines for the Cross-ministerial Strategic Innovation Promotion Program.

(2) Schedule for Implementation

- The prior evaluation, the evaluation at the end of each fiscal year, and the final

evaluation will be performed.

- After completion, a follow-up evaluation will take place after a certain period (generally in three years) if necessary.
- In addition to the above, it is possible to perform a mid-year evaluation if necessary.

(3) Evaluation Items/Standards

Based on the General Guideline for the Evaluation of Government Research and Development (R&D) Activities (Decided on Dec. 21, 2016 by the Prime Minister), the evaluation items/standards are as listed below, from the viewpoint of evaluating the need, efficiency, validity, and so on. In the evaluation, not only the judgment of achievement/failure is given but also the analysis of its causes and factors, and proposed improvement measures are given.

(i) The importance of its meaning, and compatibility with the goals of the SIP system
(ii) The validity of its objectives (especially the outcome-oriented goals), and the degree of achievement of the process schedule for achieving the objectives
(iii) Whether appropriate management is performed. Specifically, the way in which the effect of cooperation with ministries and agencies is demonstrated
(iv) The strategic characteristics and the degrees of achievement for practical application and industrialization
(v) For final evaluation, its prospective effects or ripple effects. Whether the method of follow-ups after completion is appropriately and clearly set

(4) How to Reflect Evaluation Results

- The prior evaluation shall be performed for the plans of the next and following fiscal years. Its result should be reflected in the plans, and so on, of the following fiscal years.
- The evaluation at the end of a fiscal year shall be performed on the actual results up to that fiscal year and on the plans for the next fiscal year. Its result should be reflected on the plans, and so on, of the next and following fiscal years.
- The final evaluation shall be performed on the actual results up to the final fiscal year. Its result should be reflected on the follow-ups after completion, and so on.
- The follow-up evaluation shall be performed on the progress of practical application/industrialization of the results of each issue, and improvement measures should be proposed.

(5) Disclosure of Results

- The evaluation results should be disclosed in general.
- The governing board for evaluation should not be disclosed, as it includes confidential research and development information.

(6) Self-Assessment

Before the evaluation at the end of each fiscal year by the governing board, a self-assessment by the research director and the PD and management entities shall be performed.

(i) Self-Assessment by Research Director

Before evaluation, if the research director for each project is decided, then the research director shall perform the self-assessment.

The research director shall perform assessment on the actual result after the last evaluation and the future plans, applying the evaluation items and standards given in 5. (3)., and summarize not only the judgment of achievement/failure, but also the analysis of its causes and factors, and propose improvement measures.

(ii) Self-Assessment by PD

The PD shall refer to the results of self-assessment by the research director, and also to the opinion of a third person, if necessary, to perform self-assessment on the actual result by NEDO and each research director and the future plans, applying the evaluation items and standards given in 5. (3), to summarize not only the judgment of achievement/failure, but also the analysis of its causes and factors, and propose improvement measures. Using the results of this self-assessment, the continuation of research will be decided for each research entity, and also some necessary advice will be provided to the research directors. This shows that the structure may be improved autonomously.

Based on the results of this self-assessment, the PD sends reports to the governing board with the support of NEDO.

(iii)Self-Assessment by Management Entities

The self-assessment by NEDO shall be performed to confirm that the administrative procedure for budget execution was properly executed.

6. Exit strategy

(1) Promotion of Exit-oriented Studies

- To encourage participants to create new services and businesses by having end-users (including companies) participate from the initial stage of development, and by having developers and diverse users conduct demonstration experiments using developed technologies by controlling multimodal information properly and safely, by establishing an advanced human interaction platform technology that enables cooperation between human or by assisting and augmenting human cognition and behavior by utilizing big data and AI, or by collaborating between human and AI in areas where automation is difficult and collaboration between human and AI is considered effective (nursing care, education, customer service, and so on).
- Specifically, to develop technologies for the verbal/nonverbal multimodal dialogue processing technology that supports effective and efficient communication in social life and at industry sites, the technology that supports the cognitive behavior of elderly persons, the technology that supports the development of human resources and learning to obtain new knowledge and skills with the shift in industry structure, to start other interaction support industries of the system that includes human and AI, and to lead the world.
  - As for the intra-domain data exchange platforms, to promote the maintenance of vocabularies, metadata, API, and so on, to secure interoperability with the data exchange platform by field, to verify in specific fields and areas (such as local governments), and to develop step by step through the PDCA cycle. After that, the management of the platform will be gradually transferred to the private sector, such as private consortiums, under the constant control of the national government, to form an ecosystem that can operate independently and sustainably.
- After construction of the AI-based automatic negotiation platform, it will be handed over to private consortiums and other organizations to encourage private-sector companies to develop various applications.
- To discuss specific social implementation by seeking cooperation with other relevant SIP issues such as the "digital data processing platform technology in physical areas," "cyber physical security for IoT society," "smart logistics service," and "technologies for smart bio-industry and agriculture". To seek strong cooperations, in particular, with the projects of "digital data processing platform technology in physical areas," and to achieve advanced integration of the cyberspace and physical space.

(2) Measures for Propagation

- To set a research topic that is compatible with on-site challenges like business succession (transmission of skills) due to "aging" and "lack of manpower" that many small and medium-sized enterprises (SMEs) and small-scale enterprises are facing, and to link it to the social implementation, with the participation of companies, entities, enterprises, local governments, schools, developers, and users (including companies) from the early stages of research and development, and by promoting matching of the development practitioners and various users through the demonstration of platform technology.
- For the cross-domain data exchange platform, to designate the Council for Science, Technology and Innovation (CSTI) and the IT General Strategy Headquarters as the base. In cooperation with relevant ministries and agencies, private councils, and so on, to deal with issues like cyber security and personal data protection. To perform maintenance by securing interoperability with Europe and America. To form an ecosystem that can operate independently and sustainably. To create new businesses utilizing the cross-domain data exchange platform.
- For the AI technology, with the idea of open innovation, to encourage the active participation of various startup companies that provide highly innovative and specific solutions utilizing the data exchange platform, to establish an innovative technology platform, and to create a new business model that has never existed in the industrial structure of our country.
- Social implementation shall be promoted in cooperation with other projects (such as other topics of SIP, PRISM) and research institutions (such as AI3 center) of the public sector, private sector, and academia, and by utilizing this as the platform technology.
- If necessary, to perform follow-up evaluation on the progress of the practical application and industrialization of each result, and to discuss the improvement measures.

7. Other Important Topics

(1) Applicable Laws

This SIP topic is executed based on Article 4, paragraph (3), item (vii)-3 of the Act for Establishment of the Cabinet Office (Act No. 89 of 1999), the Basic Policy for Science and Technology Innovation Promotion Fund (May 23, 2014, the Council for Science, Technology and Innovation), the 2nd term of the Implementation Policy for the Cross-ministerial Strategic Innovation Promotion Program (SIP) (implemented with the supplementary budget for FY2017) (Mar. 29, 2018, the Council for Science, Technology

and Innovation), the Operational Guidelines for the Cross-ministerial Strategic Innovation Promotion Program (May 23, 2014, the governing board of the Council for Science, Technology and Innovation), and Article 15, item (ii) of the Act on the New Energy and Industrial Technology Development Organization for the National Research and Development Agency.

(2) Flexible Change of Plans

This plan shall be reviewed according to circumstances to accelerate and maximize the outcomes.

(3) History of PD and Person in Charge

(1) PD

Yuichiro Anzai
(from Apr. 2018)

(2) Councilor in charge (Director)

Takao Nitta
(from Apr. 2018)