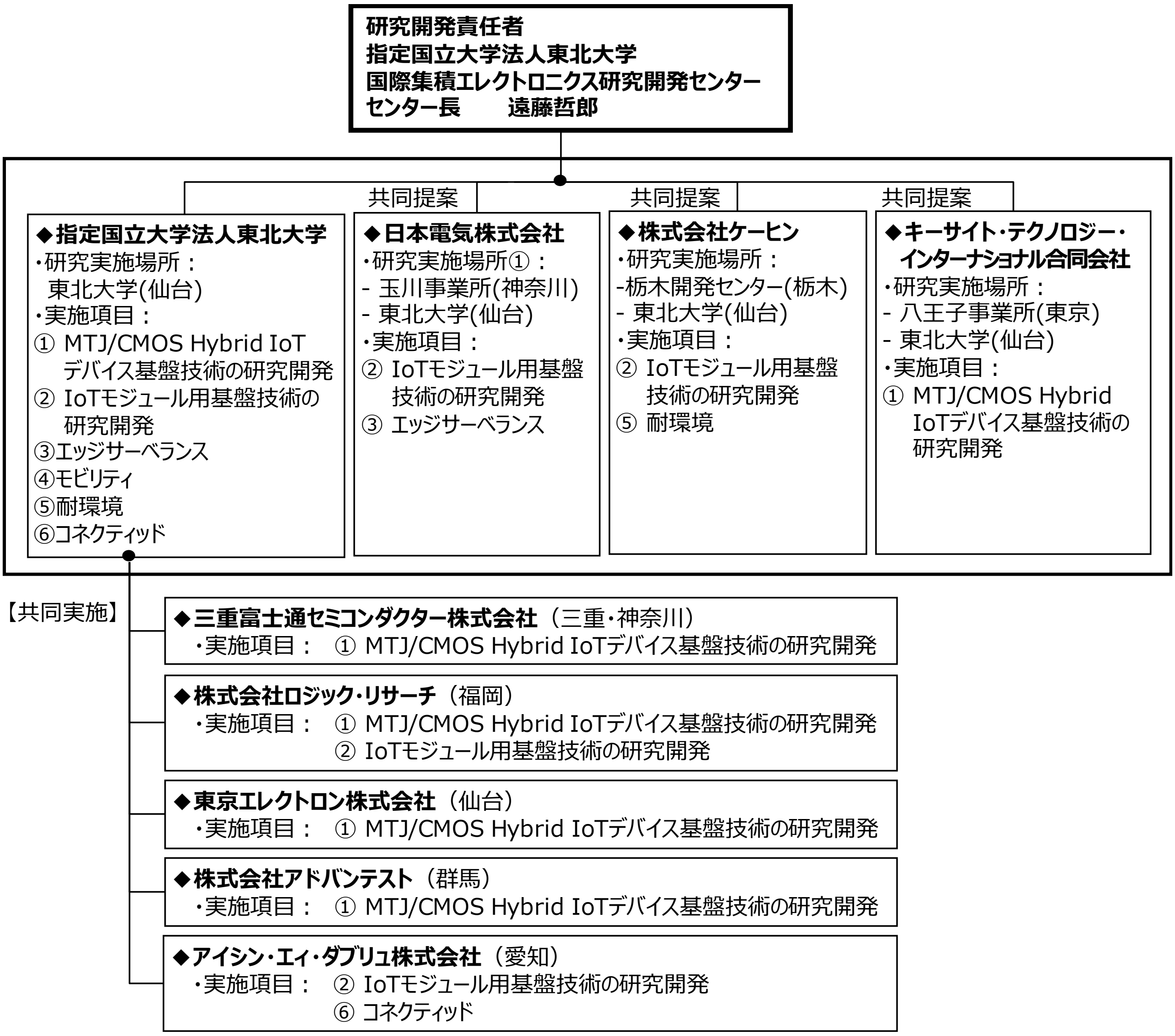


Figure 2-24. Research Organization Strategy

Issues	Further advanced arithmetic processing functions are required from IoT devices to reduce the volume of information traffic between physical space and cyberspace. However, it is very difficult to realize the arithmetic processing function required for permissive power consumption in the edge-side system with only limited power supplies, through IoT devices based on the existing technologies. This is one of the major technical challenges concerning core technologies for IoT devices in support of Society 5.0. Furthermore, due to lack of highly practical IoT devices, the development of necessary module core technologies and systemization core technologies has been delayed, and major IoT projects that will support society have not commenced. This is also a major issue for the physical space industry, for which the integration of core technologies with applications is important.

Positioning of Research and Development	In this proposal, through the use of core technologies for MTJ/CMOS hybrid integrated circuits where CMOS technologies are merged with magnetic tunnel junctions (MTJ), which are regarded as the closest to commercialization amongst the spintronics elements that have been developed by the proposers in Cabinet Office “Impulsing PAradigm Change through disruptive Technologies (ImPACT)” projects, and others, IoT devices will be merged not only with the arithmetic processing function, but also with the non-volatile function (the function for retaining information even after the power-off). This will resolve the conventional dilemma between power consumption and arithmetic processing performance, increase the arithmetic processing performance relative to power consumption by a factor of five to ten, and construct core technologies for the IoT devices required in physical space.
Advantages	No other IoT devices that have the arithmetic function, the non-volatile function, and high practicality have been developed. On the other hand, Tohoku University has been taking the lead in the world in MTJ/CMOS Hybrid technologies, as well as pioneering work for MTJ devices, and has technical advantages. Ripple effects of “the innovative protection and security technology that will create services directly related to the manufacturing industry and the lives of people, innovative technology for supporting nursing care and the lives of people, innovative automobile traffic systems, innovative manufacturing (“monozukuri”) systems, including robots, innovative energy-saving technology, innovative three-dimensional map information utilization technology, and innovative support for remote medical and nursing care, etc.” created by construction of core technologies for innovative low-energy IoT devices. The construction of the module technology and the systemization core technology for promoting social implementation of the core technologies mentioned above through this research and development will be so great that they will contribute to further enhancements of international competitiveness of the IT industry, automobile-related industries, and semiconductor-related industries, with which Japan (including the companies participating in this program) retains its global presence.
Others	Tohoku University will utilize core technologies that have been developed by proposers and others in the Cabinet Office ImPACT programs, determine application fields for the technologies created through this research and development in Society 5.0, extract requirement specifications and solve technical challenges through back casting, construct a research scheme composed of IT companies, automobile companies, twelve device/design/manufacturing equipment/measuring equipment manufacturers, along with three cooperating universities, and promote research and development. Tohoku University will collaborate with the Ministry of Economy, Trade and Industry and NEDO in core technologies for MTJ/CMOS Hybrid IoT devices, and construct systems capable of maintaining the edge platform through standardization and public disclosure. In addition, the university will collaborate with Miyagi Prefecture, as well as with the advanced electronic and machinery industries and the automobile industry, which form the core of the prefecture’s manufacturing industries, via the Miyagi Advanced Electronic and Machinery Industries Association (425 companies/groups), and Miyagi Automobile Industry Association (610 companies/groups), from the initial stage of this research and development, with the aim to achieve Society 5.0 in the region.

Figure 2-25. Issues, Positioning, Advantages, and Other Aspects of the Research

[Goals of the Relevant Fiscal Year]

<Development of core technologies for systemization>

To improve the evaluation environment, make prototypes of IoT modules by using MTJ-based non-volatile microcomputers obtained through ImPACT, improve the software development environment such as firmware, and perform early demonstration, thereby extracting development issues of core technologies for systemization. To provide feedback of the extracted issues to the development of core technologies for IoT devices/modules.

<Development of core technologies for IoT devices>

To use equipment introduced in the previous and current fiscal years to obtain device parameters for test chips, and enhance the IP library and PDK in connection with the research and development of core technologies for MTJ/CMOS Hybrid IoT devices.

To reflect the extracted issues resulting from the early demonstration mentioned above, and based on said issues, use the equipment introduced in the previous and current fiscal years to design and make prototypes of test chips, thereby contributing to the development of the IoT modules to be performed in the next fiscal year.

<Development of core technologies for IoT modules>

To promote consideration of 3D implementation of IoT modules, make GaN on Si power controllers higher-frequency and more efficient, and further attempt to extract issues towards the achievement of the final goal, the realization of the smallest and most efficient IoT modules in the world.

[Interim Goal] (as of the end of FY2020)

<Development of core technologies for IoT devices>

To evaluate MTJ/CMOS Hybrid IoT devices designed and prototyped in FY2019 on the basis of back casting from the four commercialization strategies: mobility, edge surveillance, environmental resistance, and connectedness. Then, to perform verification examination on the reduction of power consumption to between 1/3 to 1/5 of that of CMOS-based IoT devices, extract issues toward the achievement of the final goal, and hand over the extracted issues to core technologies for IoT modules and systemization. To integrate device parameters for test chips with the integrated process performance to construct the primary PDK, and further integrate the developed circuit IP. To promote various types of development for solving the extracted issues, make prototypes out of samples that have been made halfway through the previous fiscal year, and promote examination toward demonstration chips. To upgrade the basic MTJ device parameters extraction tool that will be necessary for construction of PDK and circuit IP, in parallel with said evaluation of chips and additional small-sized prototyping.

<Development of core technologies for IoT modules>

To complete primary prototyping and evaluation. Then, to use simulation to confirm the possibility of size reduction to 1/5 of the conventional technologies, and reduction of energy consumption to 1/10.

<Development of core technologies for systemization>

To promote consideration and performance evaluation of systems by using the results of the evaluation of test chips made as prototypes in FY2019, provide feedback of the extracted issues to the development of core technologies for devices/modules, and confirm the possibility of achievement of the final goal by using simulation.

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

<Development of core technologies for IoT devices>

To perform verification examination on reduction of power consumption to between 1/5 to 1/10 of that of CMOS-based IoT devices, integrate the integrated process performance with the device parameters used for the verified IoT devices, construct PDK, integrate the developed circuit IP as well to form a common platform, and reduce the development costs to 1/10. Furthermore, to integrate the modeling technology with the construction of MTJ device parameters measurement systems for various IoT devices using the MTJ/CMOS Hybrid technologies required for construction of the secondary PDK and circuit IP.

<Development of core technologies for IoT modules>

To realize a size reduction to 1/5 of the conventional technologies, and reduction of energy consumption to 1/10. In addition, to estimate the development period and cost reduction in collaboration with the subthemes.

<Development of core technologies for systemization>

To demonstrate that utilization of core technologies for MTJ/CMOS Hybrid IoT devices will reduce power consumption performance to 1/5 of that of the existing IoT devices in TRL 5 to 7, on the basis of prototyping of demonstration chips.

Research Project No.: PII-2

Research Project Name: Development of Sensor Systems as Human Interaction Device

Principal Investigator: The University of Tokyo

Co-Proposer: National Institute of Advanced Industrial Science and Technology

Dai Nippon Printing Co., Ltd.

Ricoh Co., Ltd.

ConnecTec Japan Corporation

Issue to Be Solved: Research Overview: In this proposal, we will conduct development of innovative sensors, and developments related to the real application of such sensors, that will collect as contact information high-value information that heretofore could not be obtained using various 3-dimensional interfaces that people and things interact with in day-to-day environments.

Figure 2-26. Research and Development Overview

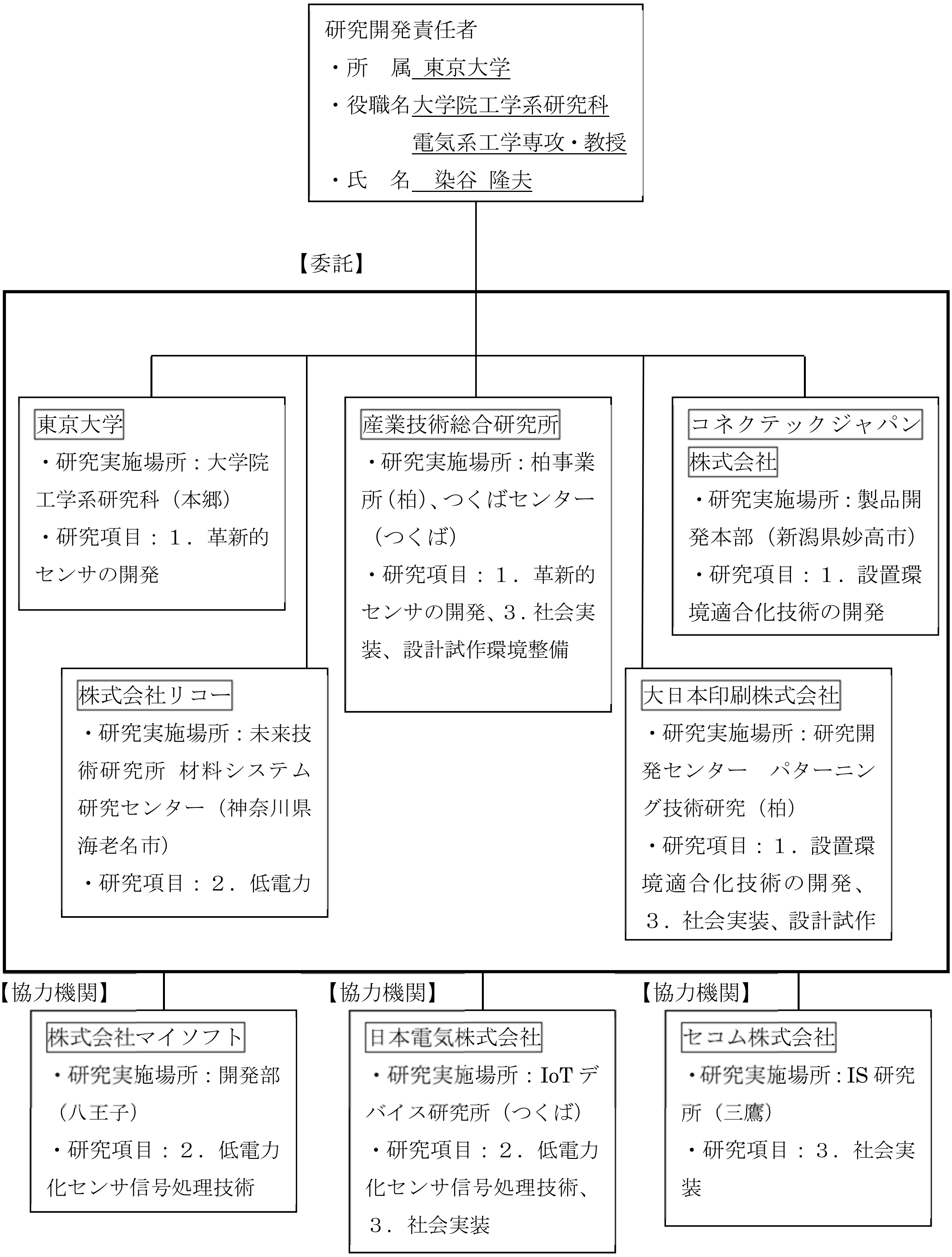


Figure 2-27. Research Structure Scheme

Issues	The development of a smart society is crucial in responding to labor shortages caused by dwindling birthrates and aging populations, increases in demand for welfare and nursing services, among other social issues, and, as a result, the efficient transfer of information from physical space to cyberspace has become a major technological issue. Although image information is currently being aggressively utilized towards this end, image information is plagued by a number of different issues, such as privacy, blind spot problems, and information overload, so the development of revolutionary sensing technology that supplements existing information collection systems has become necessary. Further, development and application of sensing technology that collects unconscious information from bio-information are sought with respect to people's living environments.
Positioning of Research and Development	This technological development will develop 3-dimensional curved surface sheet sensors, technology to implement such sensors, ad data processing technology, among others, and offer original and revolutionary sensing technology that can simultaneously collect, in real time, individualized identification and recognition as well as status information of particular subjects from contact information obtained through interfacing with people and things. These sheet sensors are characterized by adaptability to large surface areas, multiple points, arbitrary shapes, and multi-modal adaptability, and by having these sensors permeate into various things found around people, the sensors will make it possible to collect multifaced and versatile information regarding people and things that could heretofore not be collected due to limitations on installation environments, etc., and offer equipment control and services, etc. that utilizes this distinctive data. The expected ripple effects this will have on industry include effects such as increased productivity through optimization and automation of distribution and material quality management through application of the present technology, and realization of efficient welfare and nursing services that properly account for privacy. Furthermore, in addition to creating designing and testing environments that can widely apply those technologies, we will also establish a consortium with hub functionality to allow various players in IoT industry areas such as devices and services to come together, thereby disseminating technology and activating the manufacturing industry.
Advantages	In order to create information collection systems that efficiently utilize only necessary data in real time, crucial technological issues such as multi-modulization, heavy integration, adaptation to installation environments, and selection of necessary information will need to be addressed. Today, we can see focused, enhanced efforts to advance in each issue both within and without the country, but no organization yet exists that collectively applies these issues in practice to sensing. The present technological development will conduct development by collectively integrating all of the issues described above, and has an advantage in being able to provide a sensing system that allows for utilization of such information. The development will place particular focus on contact information, and is advantageous as an information gathering method by extracting only necessary information, allowing it to supplement areas for which traditional imaging is poorly suited, such as information overload, privacy violations, and information gathering from areas in blind spots.
Others	The present technology is based on bio-harmonizing sensor technology and flexible sheet sensor technology developed as part of a project crossing various government ministries, such as the "Bio-Harmonized Electronics" of the JST Strategic Basic Research Programs (ERATO) and the "Development of Basic Technology for Next-Generation Printed Electronics Materials and Process Technology" of NEDO, and has been researched and investigated as part of NEDO's Energy and Environment New Technology Leadership Program for appropriateness, validity, and advantageous positioning as part of the sensor technology necessary for creating a smart society as part of the "multi-modal, high-integration, multi-point distribution information sensor technology development."

Figure 2-28. Issues, Positioning, Advantages, and Other Aspects of Research

[Goals of the Relevant Fiscal Year]

Implement prototype testing of elastic sensor sheets, etc. that have been given multi-point and multi-modal functionality, and, in addition to beginning demonstrative testing with users, acquire new users via deployment at exhibitions, etc.

[Interim Goal] (as of the end of FY2020)

Deliver testing environment and design tools in order to support new participation by businesses into sensor development.

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

Complete analytical technology necessary to utilize data collected through multi-modal sensors in services, and begin investigating commercialization of such services.

Research Project No.: PII-3

Research Project Name: Smart IoT Environment Sensors with a Thermal Harvester at Ordinary Temperatures

Principal Investigator: Tohoku University

Co-Proposer: Mitsui Chemicals, Inc.

Research Overview: Develop smart IoT environmental sensors that generate and store power as well as activate from low-quality heat sources. By demonstrating smart distribution technology such as loggers of raw food status through field testing, we will develop, in the future, compact IoT environmental sensor systems that can be expanded into safety and security of food products and agriculture.

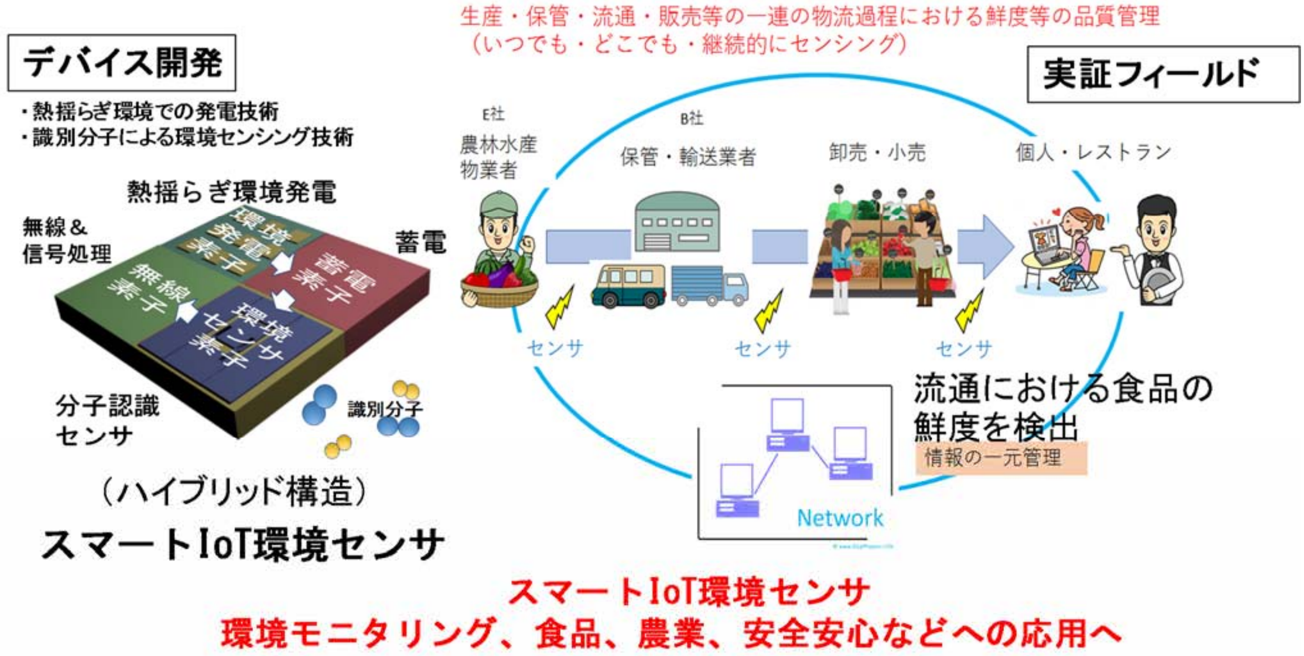


Figure 2-29. Research and Development Overview

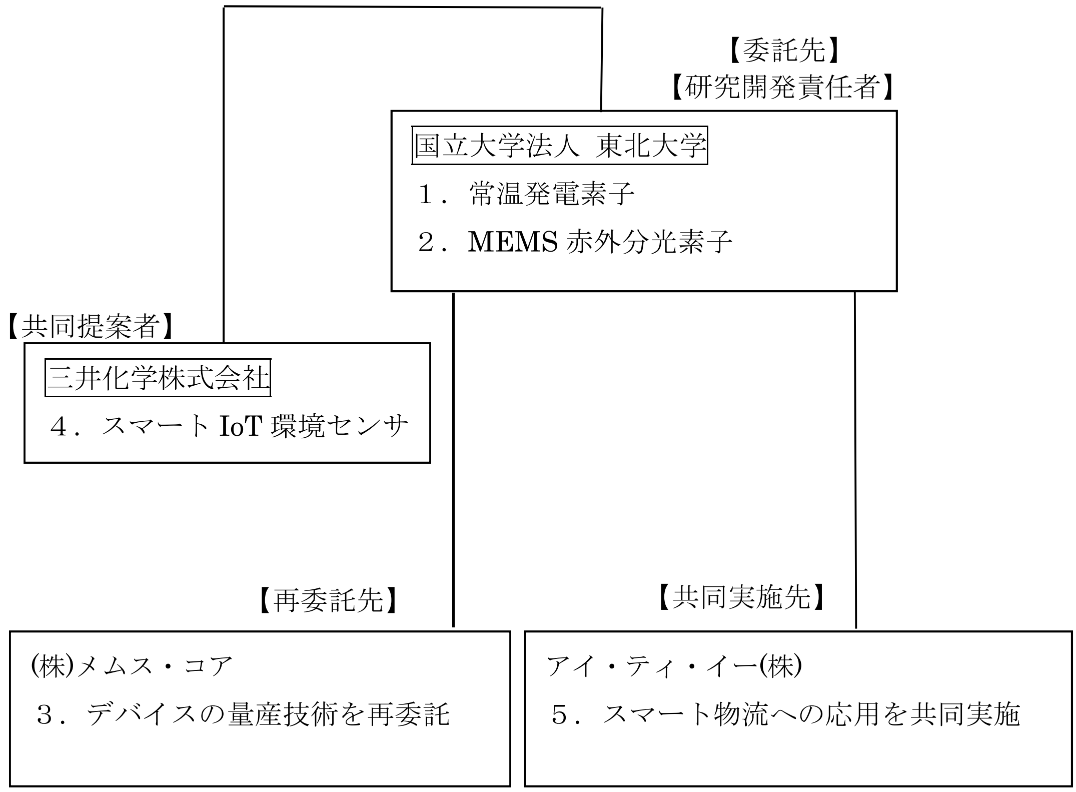


Figure 2-30. Research Structure Scheme

Issues	IoT sensors, which acquire physical information in order to realize a smart society, are expected to operate in a variety of locations and environments, and require compact and inexpensive sensor systems that ideally operate without being supplied with power. Realize new ordinary temperature environment power generation that generates power from low-quality heat sources, combine this with low-energy IoT sensors to demonstrate molecule recognition sensors (environmental sensors) that operate without a power supply, and develop IoT sensor systems that can be applied to food safety and security, environmental sensors, and gas detection, among other areas. This development will utilize common edge computing platforms to accelerate development, and contribute to the realization of Society 5.0 through coordination with the third R&D subtheme.
Positioning of Research and Development	・ Develop systems to generate power from low-quality heat sources and supply energy to IoT sensors (ordinary temperature power generation). ・ Develop compact, efficient, and mass-production compatible thermoelectric, power storage elements, and achieve high efficiency ordinary temperature power generation. ・ Develop new, low-energy consumption molecule recognition sensors. ・ Utilize as smart IoT environment sensor systems. ・ Conduct demonstrative testing for potential use in safety monitoring of food and medical supplies in smart distribution. ・ Develop systems with the expansibility to be applied in areas such as future environmental monitoring and smart agriculture. ・ Contribute to realization of Society 5.0.

Advantages	Molecular recognition sensors of each variety are being developed within and without Japan, but no one has yet realized a system that can detect multiple low-concentration molecules at ppm or under. By utilizing a new sensor system using the functional polymer technology possessed by participating members, we can be the first in the world to realize IoT sensors with highly sensitive molecular identification functionality. Furthermore, our group possesses the top technology for the development of thermoelectric materials capable through processes capable of mass production, and by expanding this technology to the level of practical application, we can hybridize it with IoT sensors, and be the first in the world to realize operation without a power supply.
Others	The development environment of the Micro System Integration Center utilizes the results of the formation program of JST's leading fusion innovation creation base (FY2007 through FY2016). The present research is conducted in coordination with members of industry and academia, such as Tohoku University, Mitsui Chemicals, Inc., MEMS Core Co., Ltd., and Innovation thru Energy Co., Ltd., and future coordination with Miyagi Prefecture is also being considered. Furthermore, coordination with the Ministry of Land, Infrastructure, Transport and Tourism and other "smart distribution" of SIP can also be conceived.

Figure 2-31. Issues, Positioning, Advantages, and Other Aspects of Research

[Goals of the Relevant Fiscal Year]

Create a theoretical model of ordinary temperature power generation elements, and aim for process development and p-type materials selection. Acquire knowledge regarding design parameters, etc. through testing of compact heat-storage elements and thin-film micro super capacitors.

[Interim Goal] (as of the end of FY2020)

Test 16 cm^{-1} resolution micro spectrometers. Create a structure for implementation of distribution field testing.

[Final Goal] (as of the end of FY 2022)

Demonstrate system efficacy of IoT environmental sensor system prototype through field testing, and create a business model for social implementation.

Research Project No.: PII-4

Research Project Name: Research on Ultra-Sensitive Sensor System

Principal Investigator: Toshiba Corp.

Research Overview: In order to realize Society 5.0, we intend to create an edge computing platform that can collect, process, and analyze valuable data from physical spaces in which a diverse array of sensors have been installed, and develop an ultra-sensitive sensor system utilizing revolutionary detection principles that can simultaneously offer real-time capabilities, controllability, and low- energy consumption.

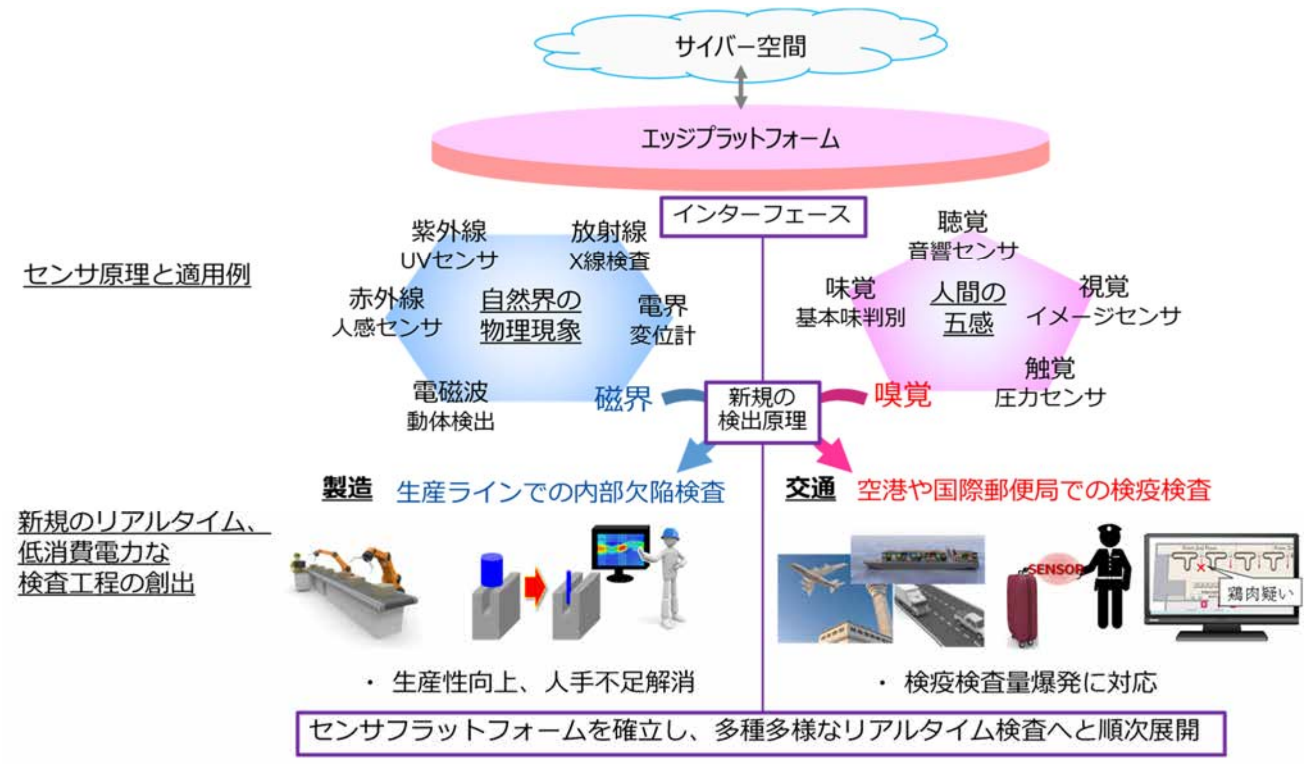


Figure 2-32. Research and Development Overview

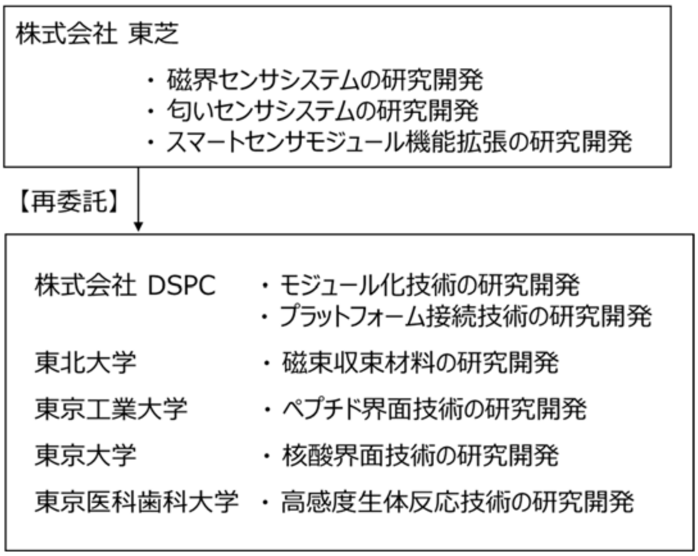


Figure 2-33. Research Structure Scheme

Issues	Traditionally, various industries have begun utilizing sensors that are based off of what can be detected through the five human sense, and off of physical phenomena in the natural world, but as making these sensors more compact or less energy intensive is difficult due to limitations on their detection principles, at present most processes involve large-scale detection using large equipment, or abandon sensor detection altogether and rely on simple inspections through tacit knowledge of skilled craftspersons. These kinds of sensory processes stand in the way of dissemination and promotion of edge computing platforms during the realization of Society 5.0, the real-time capabilities, controllability, and low-energy consumption of which will progressively become more crucial in the future.

Positioning of Research and Development	This will realize sensor element components with revolutionary detection principles that combine nano-materials like magnetic materials and two-dimensional materials, and original circuit designs and structures, as well as materials that maximize the sensitivity of sensors, in order to make the application of crucial inspection processes for which real-time visualization was impossible, possible. Specific points of application are projected to be real-time interior defect inspections of factory (batteries, EV/HEV, power stations, precision electronic devices, etc.) manufacturing lines and infrastructure (bridges, essential components of roads, buildings, etc.) inspections, and quarantine inspections of airports as well as international post offices, etc., and will contribute to the enhancement of quality management of batteries used at EVs/HEVs that are projected to disseminate as a responsive measure against global warming, as well as the prevention of reductions in productivity in the manufacturing industry caused by human resource deficiencies arising from the shrinking of the labor force, and weakening of waterside measures against dangerous materials. By using the senor platforms realized here, we can progressively expand them into a diverse array of inspection fields such as the nursing and healthcare fields, and the agricultural and food products fields.
Advantages	Reportedly competitive technologies of elemental components that can be applied to high sensitivity internal defect inspections, which are the targets of magnetic sensors, are: (1) elements with giant magnetoresistance or tunnel magnetoresistance similar to the present proposal, (2) atomic magnetism, and (3) quantum sensors with nitrogen in diamonds and hollow cores. Among these only the present proposal has taken into account specifications necessary for internal defect detection from detection sensitivity, spatial analytical capability, detection depth, element size, all the way to mass production capability. In the same vein, competitive technologies to the elemental components of scent sensors are reported to include (1) metallic oxides, (2) electroconductive polymers, and (3) bio-sensors that utilize bio-tissue such as olfactory receptors. Among these only the present proposal has taken into account specifications necessary for quarantine detection from high sensitivity to and selection capability regarding specific scents, portability, mass production capability, and real-time capability. As both proposed technologies far exceed the limitations of existing technology, they are highly competitive at the international level.

Figure 2-34. Issues, Positioning, and Advantages of Research

[Goals of the Relevant Fiscal Year]

Design and test magnetic flux concentrators (MFCs), which will become the primary technology for enhancing the sensitivity of magnetic sensors, and confirm a 50x MFC gain through simply tested original bridges as well as differential amplifier circuits. Furthermore, we will develop magnetic field sensor modules, begin developing prototype systems that anticipate specific usage cases (short circuits detection of lithium ion batteries, eddy current probes of defects in the interiors of constructs, etc.), and complete investigations into compositions of systems that include magnetic field sensor modules and establishment of operational environments. Furthermore, with respect to scent sensors, in addition to confirming concentration-dependent responses to limonene, which is a citrus odor component, we will test component technologies for taking in odorants from the atmosphere and confirm feasibility as a scent detection module.

[Interim Goal] (as of the end of FY2020)

With respect to magnetic field sensors, we will test a low-noise module that conducts wavelength separation and detection of tested elements and their outputs as well as differential amplification, and confirm high sensitivity that is 50x (pT level) greater than traditional technology. Furthermore, with respect to scent sensors, conduct testing of modules designed to take in and detect scent particles at the ppm level from the actual atmosphere, and conduct operational testing. In addition, confirm specifications of interfaces that connect such sensor devices to edge computing platforms.

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

Complete testing of defect inspection functionality of high-sensitivity magnetic field sensor modules. Specifically, continue noise reduction of differential amplification, and realize 1 mm level defect detection at 1/10 of the traditional size elements. For scent sensors, realize technology to detect thin scent molecules at the detection dog level (ppb level), and demonstrate use in quarantine inspections via demonstrations at actual airports.

[Final Goal]

Realize low-energy IoT chips and innovative sensor technology and establish technology that will make it possible to conduct measurements in environments where installation was heretofore impossible, by reducing the power necessary for neighborhood processing of sensors to 1/5 or less, reducing sizes of sensors to 1/5 or less, and reducing development costs to 1/10 or less, among other improvements. By systematizing standard technological foundations, we can easily conduct social implementation through edge computing PFs described in the first R&D subtheme, eradicate obstacles to participation by small to mid-sized enterprises and ventures and industrialization, and promote the creation of IoT systems.

III. Technology to Disseminate IoT Devices for Realizing Society 5.0

Director in Charge of Subtheme: Sadao Kawamura (Professor, College of Science and Engineering, Ritsumeikan University)

Director in Charge of Subtheme: Norio Kodaira (Mitsubishi Electric Corporation)

The present subtheme is comprised of 2 research and development projects. The following are shared items between, and individualized details for each project.

[Goals of the R&D Subtheme]

In the third R&D subtheme, with the aim of realizing Society 5.0, technologies to disseminate IoT devices in society will be developed. These technologies will promote the introduction and use of robots and other IoT devices in manufacturing processes where such devices have not yet been applied, nursing care, transportation, and service areas (areas like food product factories where shape and hardness are issues, small-scale autonomous mobility services that require group controls (autonomy and synchronization between multiple units) for which communication speed, etc., is an issue).

As such, R&D activities will be carried out with the utilization of the common edge computing platform developed under the first R&D subtheme described above in mind. Technologies to encourage the dissemination of CPS in society include enhancement of real-time processing, which has limitations when used in a cloud application (technology to make materials or parts data intelligent through multi-point sensing), and technology to coordinate controls in physical space with controls in cyberspace (local level optimized controls through sensing modules, etc.) with cyberspace.

The results of the first and second R&D subthemes will be reflected as of this social implementation, and by providing feedback to the first and second R&D subthemes regarding the results of this social implementation, we will achieve high efficiency, high functionality, and high added value of the system as a whole, and demonstrate the establishment of the intelligent knowledge processing infrastructure, which is a research issue of the present program.

In addition, investigating models that conform to regions will be crucial in resolving social issues, and this R&D subtheme will also implement investigations into models that conform to regions.

<u>Research Project No.: PIII-1</u>

<u>Research Project Name: Development and Implementation of Sensor-Rich Soft End-Effector System (SSES) for Cyber Physical System (CPS) Construction</u>

Principal Investigator: Ritsumeikan University

Co-Proposer: Yamagata University

Chitose Robotics Inc.

Man-Machine Synergy Effectors, Inc.

Research Overview: Develop end effectors equipped with flexible and diverse sensors in order to develop cyber physical systems (CPS). These will be installed into mechanical systems, such as robots, realize work intended for the physical space, and achieve conversion into data in cyberspace. The developed systems will realize far-reaching reforms in industries with low work productivity.

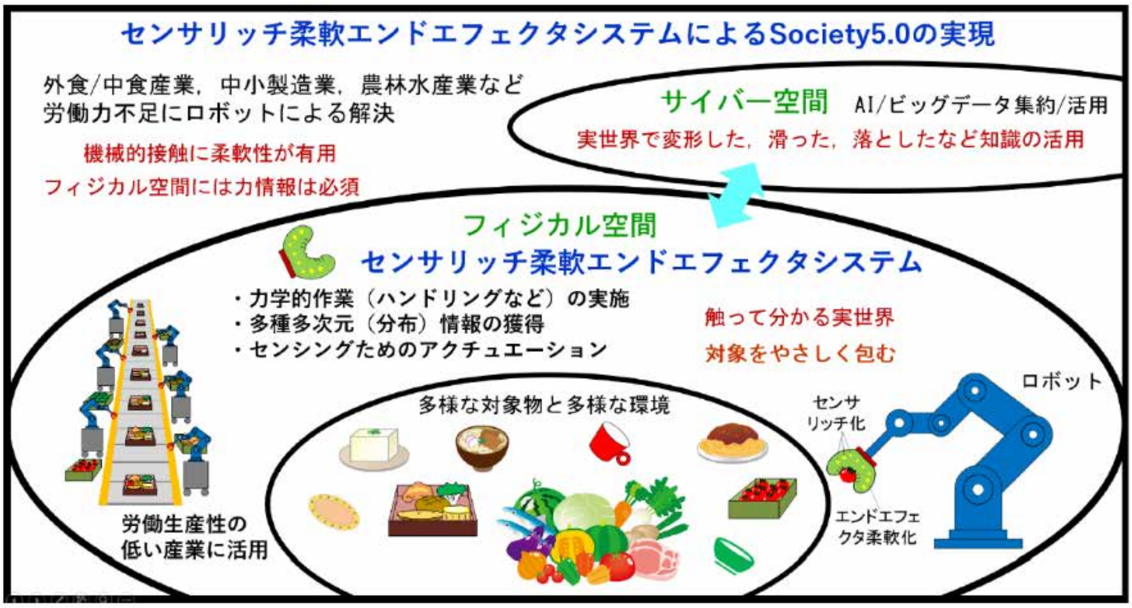


Figure 2-35. Research and Development Overview

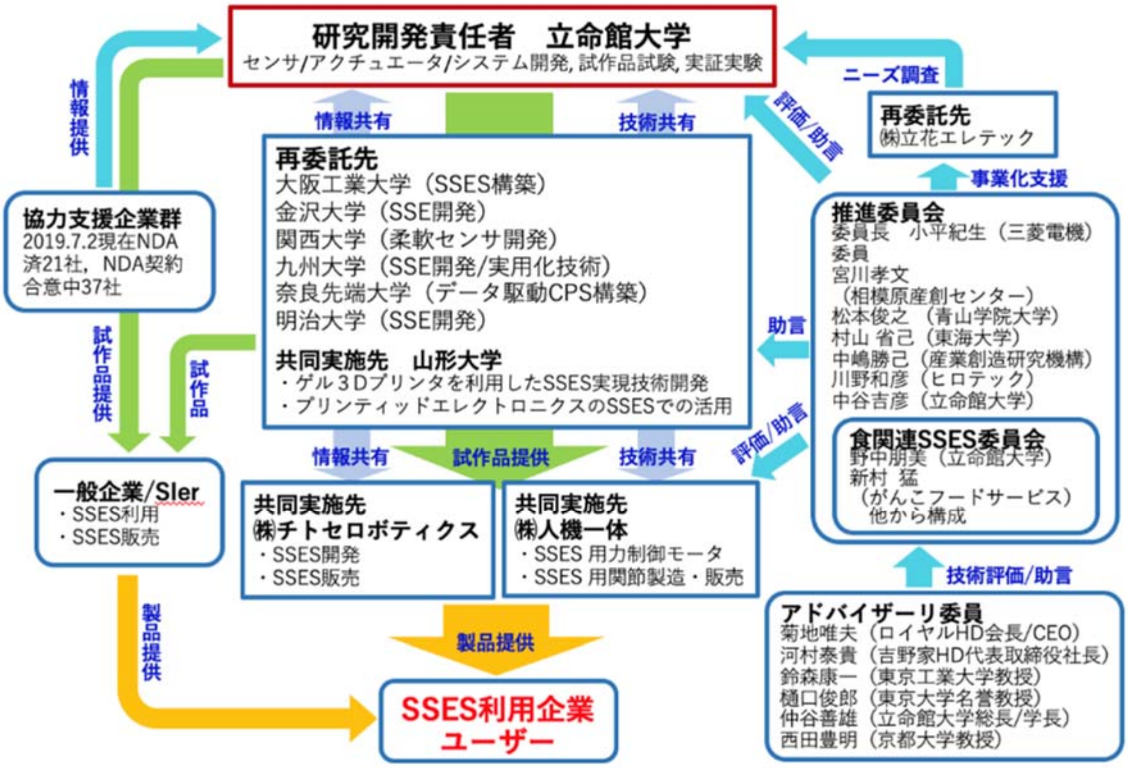


Figure 2-36. Research Structure Scheme

Issues	Many industries, such as the manufacturing industry and the food industry, have handling work involving various subjects in changing environments. This sort of work requires deft integration of determination/recognition functions with physical handling. As a general matter, managing this sort of work with existing IT and IoT technology alone is difficult. As a result, industries centered on this sort of work continue to experience low work productivity, and worsening deficiencies in human resources. This research and development will realize, as a CPS, an end effector system that is flexible and replete with sensors utilizing IoT technology that allows for handling of subjects with variegated characteristics in a changing environment, and will contribute to revolutionizing industries with low work productivity.
Positioning of Research and Development	・ Allows for acquisition of scientific knowledge of various physical operations through integration of visual and tactile information and big data technology. ・ Can contribute to fundamental research in the soft robotics field needs driven from society. ・ Makes collection of new big data with SSES as a foundation possible. ・ Allows for new industrial development such as SSES manufacturing, sales, and services. ・ Can contribute to resolving human resource deficiencies in labor-intensive industries such as the food service and home meal replacement industries.
Advantages	3D printers capable of using elastic materials have been given a practical application, and now soft constructs with complex shapes can be readily made. In addition, new devices can be developed as SSESs using gel-based 3D printers and printed electronics technology developed by members of the present research group. Japan's materials manufacturers and systems integration technicians cooperating to realize sensors to detect bending and strength of various high polymer materials and flexible constructs is advantageous at the international level. In addition, usage of big data in the handling field is a new field entirely, and may be advantageously deployed in future international competition.
Others	We expect to see SSES use in areas related to the Ministry of Agriculture, Forestry and Fisheries and the Ministry of Economy, Trade and Industry, such as the food service and home meal replacement industries, and the agricultural, forestry, and fishing industries. Furthermore, we can realize contributions to increases in productivity in small to mid-sized enterprises where the introduction of industrial robots has not advanced. Coordination between material manufacturers and universities, device manufacturers and universities, user enterprises and universities, and other fundamental industrial-academic coordination has become indispensable. The SSESs developed through the present research and development will be developed with differing characteristics based on industry type, as various types will be necessary based on the goals of the work. This will create the possibility for many enterprises to develop and sell new SSESs by using the fundamental technologies of the present research and development.

Figure 2-37. Issues, Positioning, Advantages, and Other Aspects of Research

[Goals of the Relevant Fiscal Year]

- Clarify the fundamental characteristics of each component technology by using component prototypes and the like.
- Compile conceptual plans for implementation of systemization/data and IoT use.
- Conduct SSES testing and begin demonstrative testing in demonstration fields.

[Interim Goal] (as of the end of FY2020)

- Complete SSES and IoT systems.
- Conduct demonstrative testing on-site in the food service and home meal replacement industries, and achieve demonstration of SSES in the food industry.

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

- Achieve demonstration within the small to mid-sized manufacturing firm industry and the agricultural, forestry, and fishing industries.
- Expand application of SSES in areas related to the food industry throughout the country.

<u>Research Project No.: PIII-2</u>

<u>Research Project Name: Social Implementation of Self-Traveling Personal Mobility in Which Multiple Units Work Together Safely, Comfortable and Inexpensively by Edge and Cloud Processing of Moving Space Digital Data</u>

Principal Investigator: Panasonic Corporation

Co-Proposer: Suzuki Motor Corporation

National Institute of Advanced Industrial Science and Technology

The University of Tokyo

Research Overview: Achieve inexpensive, safe, and comfortable mobility to intended destinations even for mobility impaired individuals via personal mobility utilizing autonomous mobility systems. Conduct real time processing of environmental recognition and sensor information on the edge side, and on the cloud side, develop technology optimized to synchronize and control multiple units for greater efficiency.

Figure 2-38. Research and Development Overview

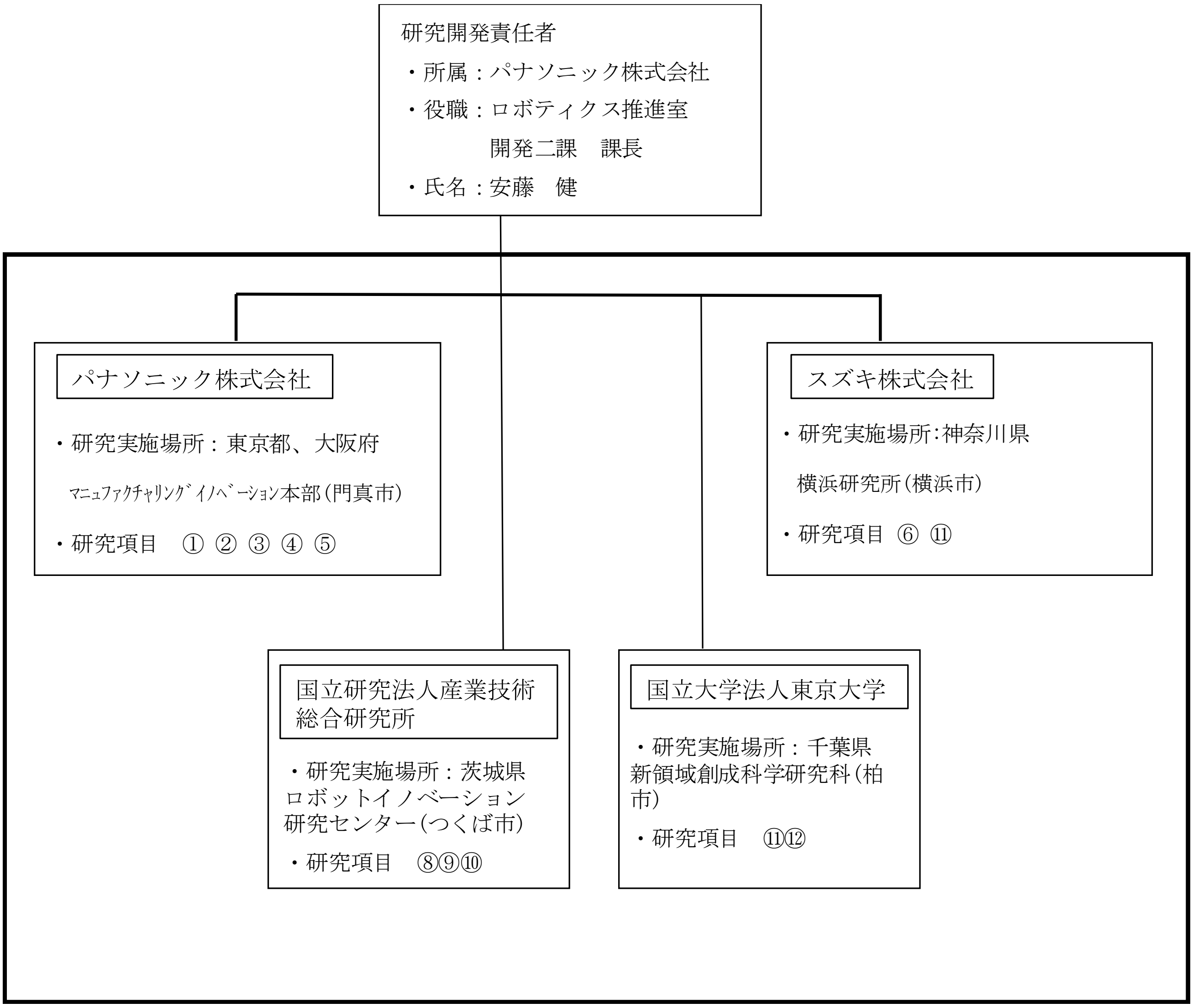


Figure 2-39. Research Structure Scheme

Issues	The goal is to resolve social issues relating to mobility that will arise with respect to changes in the demographic changes of an aging population and a declining workforce, such as: ・ Increase in mobility-impaired persons ・ Frequent occurrences of electronic wheelchair accidents ・ Deficiency of people providing mobility support among other issues.
Positioning of Research and Development	Develop automated traveling technology that supports movement inside facilities such as commercial buildings or movement in exterior areas of living environments, and create a smart society that allows even mobility-impaired persons to go wherever they want to go. Furthermore, the developed technology can be applied, not just to support personal mobility, but also to the automated transport of things, and increase productivity and resolve human resource deficiencies through automation even in the distribution and other industries, which are facing a serious workforce deficiency problem.

Advantages	Panasonic has interior mobility robot technology with safety technology at its core, Suzuki has mobility technology as the top manufacturer of electronic wheelchairs, the National Institute of Advanced Industrial Science and Technology has automated mobility technology built up through wide-spread demonstrative activities and other activities, and the University of Tokyo has mobility technology that takes into account human characteristics. By combining each party's respective strengths, we can be the first to realize level 4 automated mobility capable of movement in interior and exterior environments.
Others	With respect to automated mobility in interior and exterior environments, coordinate with many government agencies (such as the Ministry of Economy, Trade and Industry, the Ministry of Land, Infrastructure, Transport and Tourism, and National Police Agency) to efficiently advance development, demonstration, and introduction.

Figure 2-40. Issues, Positioning, Advantages, and Other Aspects of Research

[Goals of the Relevant Fiscal Year]

In addition to conducting primary development of technology necessary for environment recognition on the edge side, use simulations to test operating systems on the cloud side.

Demonstrate that the developed component technologies satisfy fundamental, demanded specifications.

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

Aim for seamless movement of automated personal mobility while coordinating with operating systems and the like on the cloud side.

Additional Accelerated Research and Development

Additional Budget Implementation Item: Coordination to Accelerate Social Implementation of Edge Computing Platforms (PFs)

Principal Investigator: Kyushu University, NEC

Principal Investigator: Mobile Techno Corporation

Principal Investigator: Ritsumeikan University

Overview:

The current primary research issue for the intelligent knowledge processing infrastructure integrating physical and virtual domains is to develop PF technologies that simply and inexpensively construct and utilize IoTs (edge and actuators) that are appropriate to resolving the personal issues specific to the users themselves. In order to accelerate this technological development, what is important is not to continue development in the traditional waterfall model, but to direct technological demonstrative testing (proof of concept or PoC) and research and development to on-site issues in an agile manner, and provide feedback obtained regarding implementation conditions quickly to the upstream processes in development. As a specific effort to accelerate this process, we plan to prepare actual locations (cooking locations, food washing locations, healthcare facilities, etc.) and conduct demonstrations with the participation of actual research operators and consumers. We will efficiently collect physical data regarding people, things, and environments through this PoC, and, after extracting and processing necessary information from the edge in real time, accelerate research and development that interlocks this information with big data processing at the cyber (cloud) level, while also interlocking such information with on-site actuators (robots and hearable devices) as responses and controls based on sensing results. Furthermore, by implementing technical synchronization between physical security, which is another SIP issue, with physical security demonstrations in wireless layers that transmit, securely and in real-time, sensing data regarding on-site persons, things, and environments to PFs, we can simultaneously accelerate synergistic effects between SIPs and social implementation. We will back this series of activities, head strategic proposals such as industrial development, social implementation, and policy recommendations, and develop a working group (WG) involving third party professionals within the fiscal year as the predecessor to the acting body (consortium) needed for the utilization and application of physical data involving offerors, creators, and users, which also include stakeholders in the industry, as well as the advancement of the method for creating processing PFs.

Implementation Items:

1. By conducting technological demonstrations of the present edge computing construction PFs at the worksites of research operators and users via PoCs, providing rapid feedback regarding the demonstration results to the upstream processes in technological development becomes possible, and will contribute to the early social implementation of edge computing construction PFs. For these demonstrations, the Kyushu University and NEC team will handle the digital healthcare area, and the Ritsumeikan University team will handle the demonstrations, and accelerations thereof, in the food preparation and food washing areas. These efforts will involve not just the participation of SIP issue research operators, but also of third party cooperators, and will conduct technological development responsive to on-site issues, as well as the construction of overall systems, and demonstration structures.
2. In addition to technological demonstrations through PoCs, by starting WGs involving industry and consortium members, as well as constructors and users, in Japan and overseas, we can accelerate dissemination strategies and social implementation strategies.
3. In coordination with other SIPs, we will conduct technological synchronization with physical security, and heighten the synergistic effect between physical security and edge computing PF security strengthening technologies, particularly wireless layer technologies.

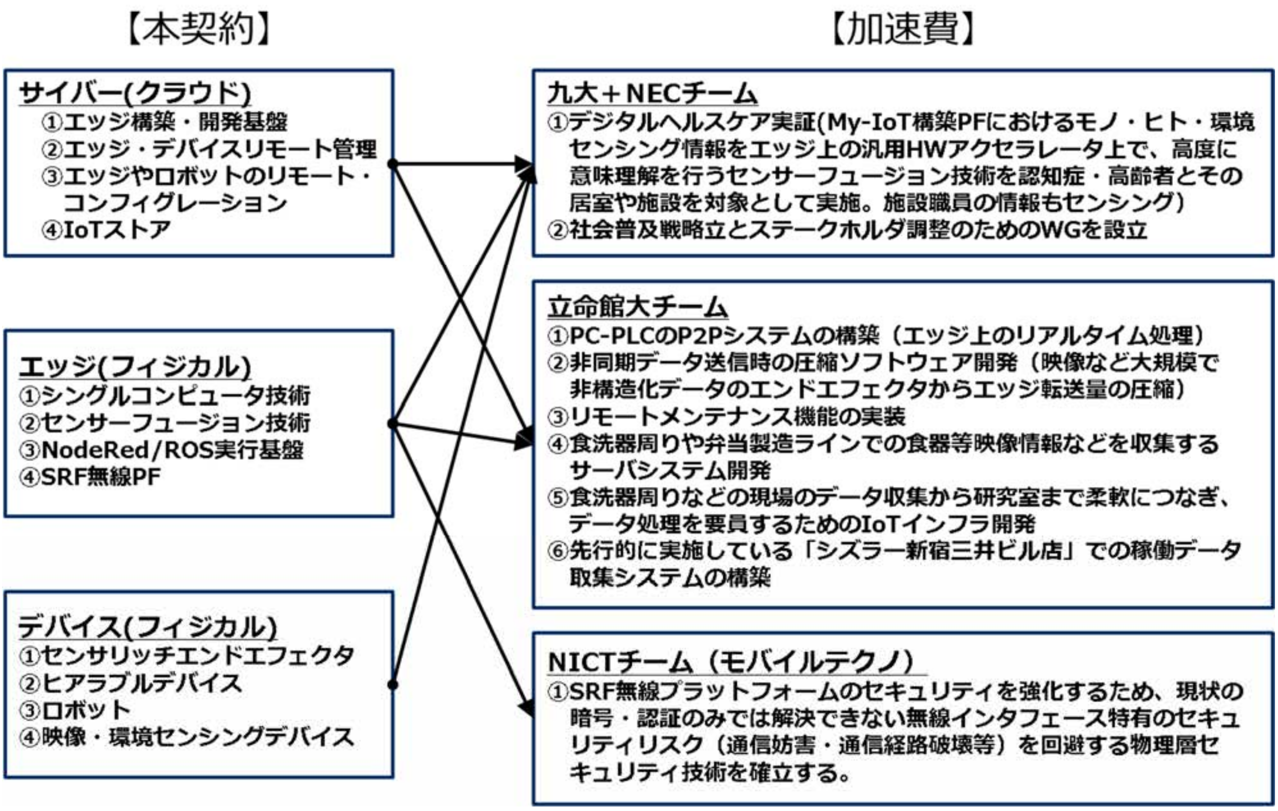


Figure 2-41. Research and Development Overview

Issues	As the current Internet of Things (IoT) system involves the vertical integration of equipment manufacturers' own product groups, IoT expansion has been limited to specific industries such as the manufacturing industry, and it is therefore difficult to say that IoT is disseminating into other industries where productivity increases and new business opportunities have become major social issues. Even robot systems are predominantly developed singularly on a case-by-case basis (PJ base development), and it is difficult to say that generalized development and construction methods have disseminated thoroughly. Furthermore, edge computing systems which are the primary sensing components in IoT systems and robotics systems that act as actuators based on sensing information each have their own independent systems and independent construction, so the workforce and time required to introduce them were also an issue. In realizing Society 5.0 and CPS, not only will the great reductions in the gaps between these constructions be expected, IoT systems and robotics systems that are organically connected as systems, and a construction and development environment where robotic systems that are controlled and operated in accordance with recognition and determinations acquired from various sensing information and the processing thereof can readily coordinate with each other and be disseminated into various industries will also be expected. Additionally, in order to secure proper activity on the part of IoT and robotics systems based on this sensing data, ensuring the security of the physical sensing data is also a pressing issue. Cyberattacks that target the vulnerabilities of IoT equipment have increased rapidly, in particular, and ensuring the safety of edge computing PFs has become a key technology to accelerating the aforementioned social implementation. With respect to edge computing PFs, which include wired and wireless networks, securing technologies to avoid cyberattacks against wireless interfaces has become a particularly pressing concern.
Positioning of Research and Development	1)Acceleration of Social Implementation of Edge Computing Construction PFs (Kyushu University and NEC team) (1) The information of multiple sensors is consolidated and treated as a virtual sensor, and, with respect to technological demonstrations of sensor fusion that conduct semantic understanding in the edge, architecture testing in the demonstration base using, in particular, data concerning a person's vitals as well as environmental data becomes possible. (2) Can contribute to the resolution of actual social issues (in particular, projection of BPSD onset in dementia patients, and

	protection of older individuals, among other efforts to allow for social inclusion and social participation by socially vulnerable persons). 2)Acceleration of Social Implementation of Sensor-Rich Soft End Effector Systems (Ritsumeikan University team) (1) Allows for acquisition of scientific knowledge of various physical operations through integration of visual and tactile information and big data/IoT technology. (2) Can ascertain status of recovered tableware as preprocessing of tableware washing automation. Furthermore, the tableware classification and recognition results can contribute to effective tableware handling. (3) IoT conversion and ROS conversion of the demonstration field will be good references when introducing sensor-rich soft end-effector systems (SSES) into production sites. 3)Coordination with Physical Security and Implementation (Mobile Techno) (1) With respect to SRF wireless platforms, avoids cyberattacks that cannot be resolved using only current passwords and certifications, such as connection interferences and connection circuit destruction that attack wireless interfaces. (2) There is significant novelty in physical layer security (multi-route secrecy distribution technology) that aggressively utilizes multiple communication routes known as multiple bands (e.g. 2.4 GHz/5 GHz) and multiple technologies (e.g. wireless LAN/Bluetooth) that have been introduced into recent wireless devices. (3) Allows for easy custom installation via software for function realization of IoT equipment, and is effective for application to manufacturing sites where 40% or more of equipment will be utilized for over 15 years. (4) May contribute to the advancement of wireless IoT conversion, not just in manufacturing sites, but also in areas such as the medical/nursing fields, where ensuring security is one of the crucial issues to be resolved.
Advantages	1)Efforts to conduct technological developments and demonstrations with actual research operators and users to actually utilize edge computing construction PFs that collectively sense things, environments, and people, and operate in conjunction with many cloud bases and general-use sensors to solve social issues (digital healthcare) are especially advanced efforts. Furthermore, operation of a work group that deliberates on edge computing construction PF technology as an ecosystem consisting not just of constructors, but also research operators and users to discuss technological development including strategies from upstream processes cannot be conducted simply with efforts stemming from private demand, and comports to policies coordinated with government agencies and elements of industry, government, and academia, which is the spirit of SIP. (Acceleration of social implementation of edge computing construction PFs) 2)Although, on one hand, sharing vocal and visual information via the Internet is quite common, sharing of dynamic information or physical information in the physical space (characteristics of tableware, dropping items, or the visual state of food on a plate, etc.) is not yet widespread. In order to widely share this physical information, this research will construct IoT systems, and, through data collection and analysis, increase the efficacy of the sensor-rich soft end-effector systems (SSESs) to be developed. Usage of IoT technology in the handling field is a new field entirely (connected handling), and may be advantageously deployed in future international competition. Further allows for real time efficient usage of information from robotic hands, which are furthest upstream, while also simultaneously acquiring useful information from data analyses conducted in the cloud, which is at the end of the data flow. (Acceleration of social implementation of sensor-rich soft end-effector systems (SSESs) 3)Ensure competitive advantage through conversion of core components of multi-route secrecy distribution technology into intellectual property (coordination with physical security and implementation)
Others	1) Acceleration of the My-IoT development platform (an edge computing construction platform) developed in the present research and development will contribute to the creation of new business models and resolution of social issues that spread across the Ministry of Economy, Trade and Industry, Ministry of Public Management, Home Affairs, Posts and Telecommunications, and Ministry of Health, Labour and Welfare. In particular, the guiding principles of “prevention” and “co-living” set by the Ministry of Health, Labour and Welfare with respect to dementia patients are things that the IoT side will accelerate realization of. 2) The connected SSES and IoT platforms that will be developed in the present research and development are expected to be used in fields coordinated with the Ministry of Agriculture, Forestry and Fisheries and the Ministry of Economy,

	Trade and Industry, such as the agricultural, forestry, and fishing industries. 3) Our activities are being done in complete coordination and inter-connection with the standardization activities of the Flexible Factory Partner Alliance (FFPA), which is the organization that advances standardization and the like with respect to wireless technology at manufacturing worksites. In particular, we are directly contributing to the creation of new business opportunities and the resolution of on-site issues relating to wireless from the perspective of wireless technology on manufacturing worksites.

Figure 2-42. Issues, Positioning, Advantages, and Other Aspects of Research

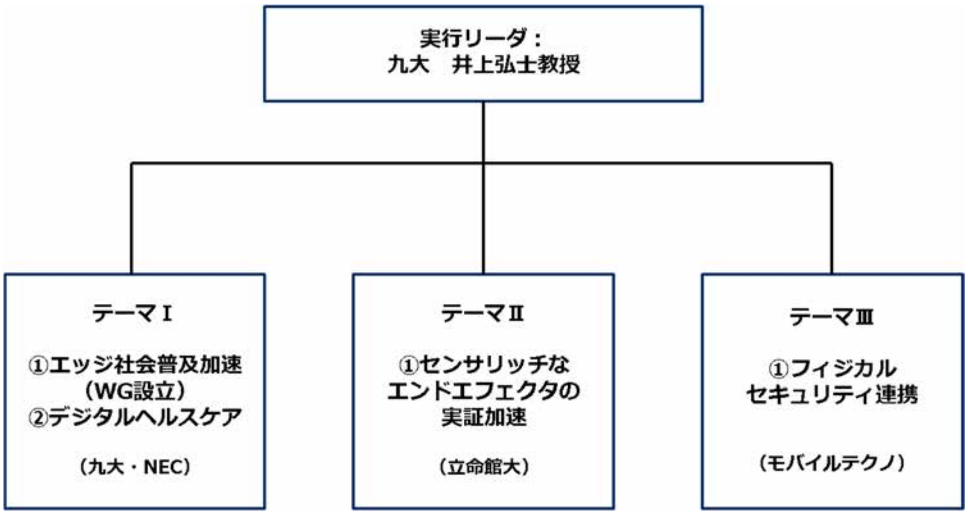


Figure 2-43. Structure

[Goals of the Relevant Fiscal Year]

Theme I:

・ Acquire digital healthcare facilities and begin advanced demonstrations.

・ Establish edge computing WGs.

Theme II:

・ Construct systems (P2P, operation approval server, periodic data reception server).

・ Collect data from the Ritsumeikan Co-Op and construct environments in demonstrative testing fields.

・ Coordinate between robots and cameras using ROS 2.0.

Theme III:

Complete development of formulas and architecture for physical layer security technology aggressively utilizing multiple communication routes (multi-route secrecy distribution technology).

[Interim Goal]

Theme I:

Analyze data and confirm results by third parties at digital healthcare facilities.

Move from edge computing WGs to establishment of consortium, and prepare for corporatization.

Theme II:

・ Construct firmware update server.

・ Collect data and construct analysis systems at Ritsumeikan University.

・ In the SIP-SSES demonstration field, collect data regarding sensors attached to hands and robot statuses into the server, and construct big data processing systems for the demonstration field.

・ Construct systems between multiple robots, robot hands, cameras, and sensors using ROS 2.0, confirm actions, collect data, and construct environments in demonstrative testing fields.

[Final Goal (Output)]

Theme I:

Start digital healthcare businesses, establish edge computing consortium, and begin monetization.

Theme II:

Complete development and testing in demonstration fields, begin horizontal deployment into other areas and commercialize.

Theme III:

Complete implementation and evaluation of multi-route secrecy distribution technology, and complete testing of functionality and performance.

Additional Budget Implementation Item: Research and Development of Multi-Sensing Module Platforms

Principal Investigator: Toshiba

Research Overview: In order to construct an IoT system oriented toward the realization of Society 5.0, highly reliable (secure) and precise recognition and determination through sensor fusion utilizing AI is indispensable. However, multi-sensing modules (MSMs) equipped with a diverse array of sensors require large costs and labor for custom development, preventing dissemination. Therefore, we will construct a platform that can readily realize MSMs that integrate multiple sensors with control circuits. This research will introduce devices and sensor technology currently under development by this program (physical space digital), as well as sensor technology Toshiba developed in NEDO-Pjs in past. The present platform creation will reduce development costs to 1/5 and development times to 1/10, and accelerate social implementation by making it easier to utilize IoT systems based on sensor fusion even in small to mid-sized enterprises and ventures.

Implementation Item: This implementation item will involve the development of multi-sensing module platforms (MSM-PFs) equipped with a diverse array of sensors. In FY2019, we will conduct investigations into existing sensor specifications and sensor interfaces, discussions with other research operators regarding the present program (physical space), and simple device testing evaluations, to implement specifications development for the multi-sensing module platforms to be developed. In FY2020, we will conduct testing of modules equipped with multiple existing sensors and microcomputers that satisfy specifications to conduct testing of sensor fusion operations that combine data from two or more sensors. In FY2021 onward, we will work on development of multi-parameter sensor fusion that utilizes AI. Additionally, we will examine prototype testing of high-added value MSMs that incorporate innovative sensors, high-speed, nonvolatile microcomputers, and the results of energy harvester technology, and complete testing for the possibility of realizing MSM-PFs that combine objective differentiated sensors and existing sensors through sensor fusion technology.

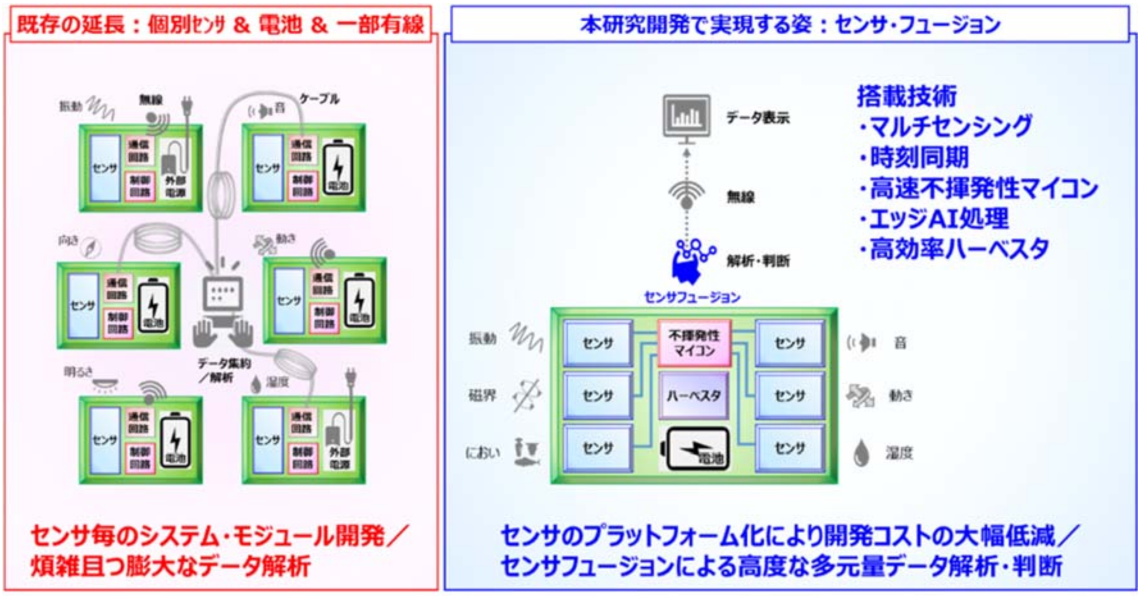


Figure 2-44. Research and Development Overview

Issues	In order to construct an IoT system oriented toward the realization of Society 5.0, highly reliable (secure) and precise recognition and determination through sensor fusion utilizing AI is indispensable. However, in order to achieve actual introduction, in addition to the development expenses of the sensor itself, significant expenses, including expenses associated with connections to neighboring circuits, including data transfer, are necessary, thereby standing in the way of dissemination.
Positioning of Research and Development	By constructing a platform that can readily realize MSMs that integrate multiple sensors with control circuits, development costs can be reduced and development times can be shortened. This will therefore accelerate social implementation by making it easier to utilize IoT systems based on sensor fusion even in small to mid-sized enterprises and ventures.
Advantages	Competing technologies to the MSM-PF of the present theme include (1) the SensorTile of ST Microelectronics, (2) SensorTag of Texas Instruments, and (3) Raspberry Pi of the Raspberry Pi Foundation. When collectively taking into account the conditions necessary for dissemination, such as size, energy consumption, development costs, and interface redundancy, the present proposal is in the most advantageous positions compared to its competitors.

Figure 2-45. Issues, Positioning, and Advantages of Research

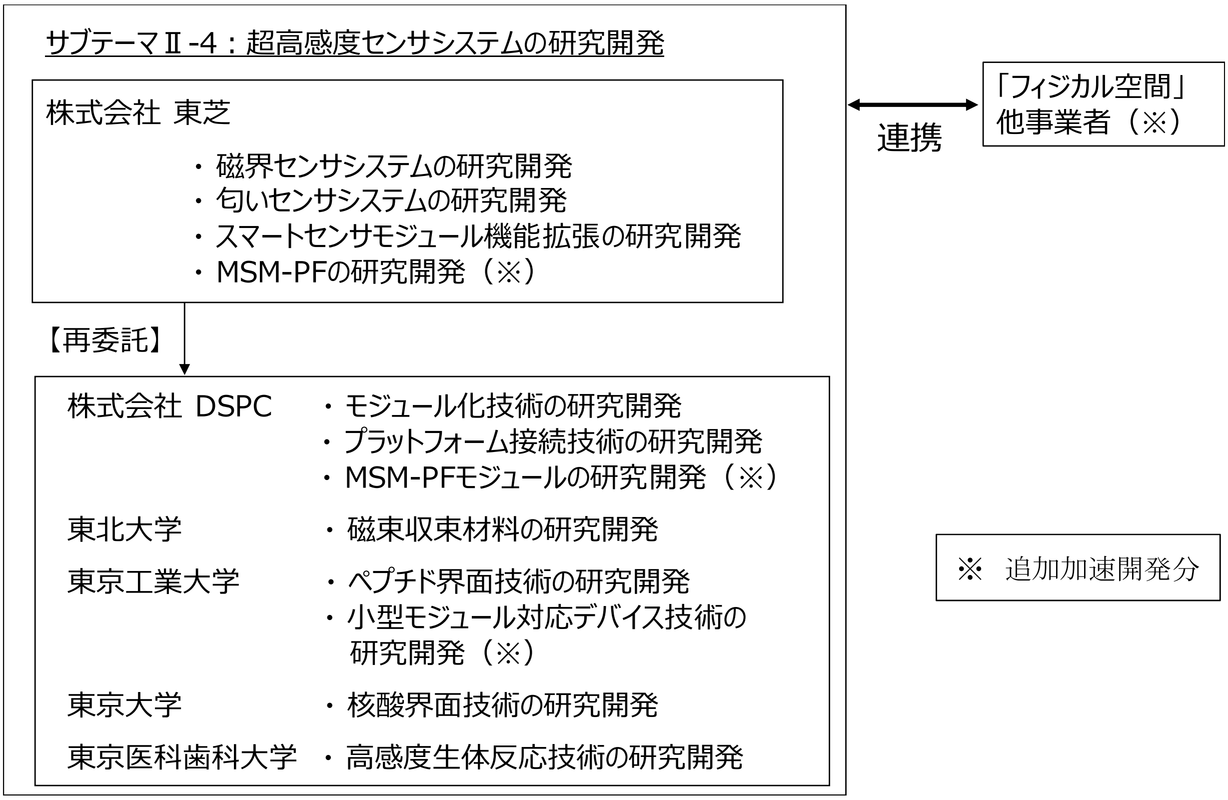


Figure 2-46. Structure

[Goals of the Relevant Fiscal Year]

Conduct investigations into existing sensor specifications and sensor interfaces, discussions with other research operators regarding the present program (physical space), and simple device testing evaluations, to implement specifications development for the MSM-PF to be developed.

[Interim Goal]

Begin testing of modules equipped with multiple existing sensors and microcomputers furnished with the time synchronization function to conduct testing of sensor fusion operations that combine data from two or more sensors.

[Final Goal (Output)]

Work on development of multi-parameter sensor fusion that utilizes AI. Additionally, examine prototype testing of highly value-added MSMs that incorporate innovative sensors, high-speed, nonvolatile microcomputers, and the results of energy harvester technology, and complete testing for the possibility of realizing MSM-PFs that combine objective differentiated sensors and existing sensors through sensor fusion technology. Verify reduction of development costs to 1/5, and development times to 1/10 through the present platform technology.

3. Implementation Structure

(1) Use of the New Energy and Industrial Technology Development Organization (NEDO)

Utilizing grants from NEDO, the present program is implemented via a structure similar to the one in Figure 3-1. NEDO will assist the PD and the Promoting Committee to manage the budget, monitor research and development progress (including monitoring of intellectual property), issue public reports and results on issues (including responses to symposia), support development of research and development plans, announcement materials, and related materials, implement peer reviews related to issues, coordinate communications with external related organizations and academic societies, accompany PD to visits of implementation organizations, conduct relevant studies and analyses, etc.

(2) Selection of Principal Investigators

Based on this plan, NEDO will select, via open application, principal investigators. The clerical work for the selection screening for the principal investigators shall be conducted by NEDO. Screening standards and the screening methods used by screeners are decided by NEDO in consultation with the PD, Cabinet Office, and government agencies responsible for policy. As a general rule, the PD as well as the case officer from the Cabinet Office shall participate in the screening. No parties with an interest in the principal investigators participating in the application shall participate the screening of that application. Furthermore, there may be situations where the scope of implementation for the research and development themes and the coordination between research and development themes, among other issues, may be considered during the screening process associated with selecting principal investigators.

(3) Implementation Structure of Research and Development

As a general rule, the research organizations, etc. of enterprises and universities, etc. (hereinafter the “organizations”) considered for selection as principal investigators shall be organizations that have research and development bases within Japan, and the participation in research and development by joint business entity structures comprised of participants from industry, academia, and government shall be encouraged. However, if there is an organization that has research and development bases outside of Japan, and there is a need to conduct research and development with such organization in order to utilize the superior research and development capabilities or research facilities, etc. possessed by this organization in a particular field, or from the perspective of meeting international standards, research and development can be implemented in coordination with such organization, but only with respect to that particular type of research and development. Note that a theme leader will be assigned to each R&D subtheme in order to maximize utilization of each implementing party’s research and development capabilities, and efficiently and effectively advance research and development, and researchers shall, to the extent possible, group themselves under this theme leader to implement research and development.

(4) Operational Management of Each Research and Development Theme

PD as well as NEDO shall be responsible for managing and executing each research and development theme, and will implement appropriate operational management in light of the program’s aims and goals, as well as the aims and goals of the present research and development, while maintaining a close relationship with related government agencies and the principal investigators. Specifically, in addition to establishing the Promoting Committee and the like and reflecting the opinions of external experts in operational management, they shall manage the progress status of research and development by receiving periodic reports regarding the progress of the research and development themes or by other means. Beyond this, they shall ascertain, at opportune times, trends in technological fields related to the research and development themes as well as changes in the external environment, among other factors, and device any necessary responsive measures.

(5) Methods of Optimizing Research Structure

In order to advance the present program using the optimal structure, PD will use the “stage gate method” for research issues, and implement active investigations into additions and changes to research issues, and rearrangement, narrowing, additions, etc. to research teams as necessary to respond to the progress status of research issues, investigation results of technological investigations and the like implemented at related organizations or other organizations, and changes in social conditions. PD shall, as necessary, assign a sub-PD to provide support for the advancement of research and development.

In order to reliably execute the management described above, and to implement coordination between research teams working on each of the research issues, PD shall hold business management conferences, and share the goals of the present issues through regular exchanges of information.

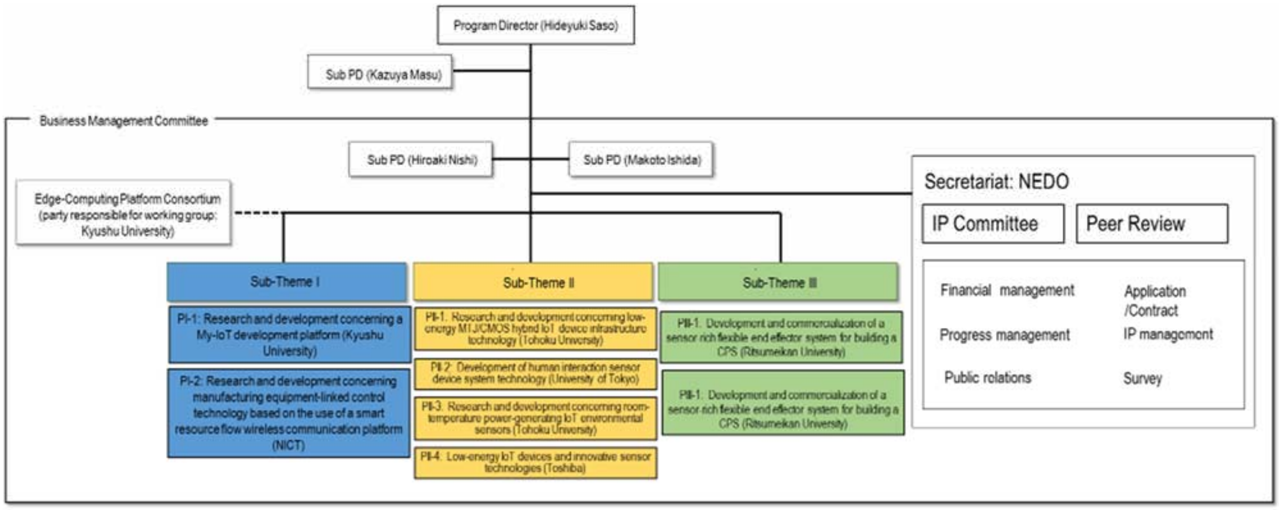


Figure 3-1. Business Management Meeting

(6) Coordination with Government Agencies

The work under this program shall be conducted and advanced in close coordination with relevant government agencies: in general, research and development for sensors, computing, etc. shall be conducted in coordination with the Ministry of Education, Culture, Sports, Science and Technology, communications portions shall be coordinated with the Ministry of Public Management, Home Affairs, Posts and Telecommunications, and devices and practical application will be conducted in coordination with the Ministry of Economy, Trade and Industry. Furthermore, the advancement of practical applications shall be conducted while keeping coordination with the business departments of the Ministry of Health, Labour and Welfare, the Ministry of Land, Infrastructure and Transport, and the National Police Agency, among others.

(7) Contributions from the Industry

We expect 10 to 20% of the total research and development costs (the total of contributions from the government and the industry) to come from future contributions from the industry (including personnel and material contributions).

4. Intellectual Property (IP)

(1) IP Committee

- An IP Committee shall be placed in NEDO, etc. or the affiliated organization of selected principal investigators (contractors) for each issue or research item that is a part of an issue.
- The IP Committee will be responsible for publishing papers on research and development results achieved by the establishing organization, as well as for determining policies toward the application and maintenance of patents and other IP rights (hereinafter "IP rights") and for coordinating IP rights licensing as necessary.
- As a general rule, the IP Committee shall consist of the PD or a representative of the PD, principal relevant parties, experts, and others.
- The organization that established the IP Committee shall determine the specifics of how the committee will be managed.

(2) IP Rights-Related Agreements

- In advance of any work, NEDO, etc. will sign contracts or other agreements with contractors to establish the handling of nondisclosure, background IP rights (IP rights already held by the principal investigator or their organization, etc. before participating in the program, as well as IP rights acquired independently of SIP program funds after participating in the program), and foreground IP rights (IP rights created within the program using SIP program funds).

(3) Licensing of Background IP Rights

- The holder of a background IP rights can license those IP rights to other program participants under conditions established by the IP rights holder (or under terms agreed upon by the program participants).
- If those conditions or other aspects of the IP rights holder's behavior risk becoming a hindrance to SIP (including not only research and development but also the implementation and commercialization of results), mediation will be conducted in the IP Committee to reach a reasonable solution.

(4) Handling of Foreground IP Rights

- As per Article 19-1 of Industrial Technology Enhancement Act, foreground IP rights shall generally belong to the organization (contractor) to which the principal investigator (as the inventor) belongs.
- If a subcontractor is responsible for an invention and the IP rights will belong to the subcontractor, or in similar such cases, the IP Committee must first give its approval. At this stage, the IP Committee can attach conditions to its approval.
- If an IP rights holder has little interest in commercialization, the IP Committee shall recommend that the IP rights be held by a party that will actively pursue commercialization, or that the IP rights be licensed to a party that will actively pursue commercialization.
- In the event that a party withdraws from the program in the middle of their participation period, NEDO, etc. has the power to transfer without compensation all or part of any patents, or issue licenses for all or part of any patents, for IP rights achieved using SIP program funds during that participation period (if the withdrawing party participated for multiple fiscal years, this applies to all IP rights achieved since the party first began participating).
- In general, the IP rights holder will cover any costs associated with patent application, maintenance, etc. In the case of a joint application, cost distribution and percentage interest in the patent shall be negotiated between the joint applicants.

(5) Licensing of Foreground IP Rights

- The holder of foreground IP rights can license those IP rights to other program participants under conditions established by the IP rights holder (or under terms agreed upon by the program participants).
- The holder of foreground IP rights can license those IP rights to a third party under conditions set by the IP rights holder, to the extent that those conditions are not more favorable than those set for program participants.
- If those conditions or other aspects of the IP rights holder's behavior risk becoming a hindrance to SIP (including not only research and development but also the implementation and commercialization of results), mediation will be conducted in the IP Committee to reach a reasonable solution.

(6) Transfer of Foreground IP Rights and the Issuance/Transferal of Exclusive Licenses

- As per Industrial Technology Enhancement Act, Article 19-1(4), the transferal of foreground IP rights and the issuance/transferal of exclusive licenses to such IP rights, require the approval of NEDO, etc., except in cases of transfer resulting from a merger or division (demerger), transfer of IP rights to a subsidiary or parent company, issuance or transfer of an exclusive license, etc. (hereinafter "IP rights transfer or similar resulting from a merger, etc.").
- An IP rights transfer or similar resulting from a merger, etc., shall require the authorization of NEDO, etc., subject to the contract between the IP rights holder and the NEDO, etc.
- Even after the conclusion of an IP rights transfer or similar resulting from a merger, etc., NEDO, etc. can hold a license with the right to sublicense for those IP rights. If the relevant conditions are unacceptable, the transfer shall not be approved.

(7) Handling of IP Rights after Project Conclusion

- If there are no claimants to IP rights after research and development has been completed, the handling (abandonment or inheritance by NEDO, etc.) of those IP rights will be negotiated through the IP Committee.

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

- The participation of a foreign organization is permitted if necessary to proceed with program tasks.
- In the interest of proper operational management, a representative or point of contact handling administrative issues pertaining to research and development contracts and similar must be located within Japan.
- IP pertaining to foreign organizations shall be shared between NEDO, etc. and the foreign organization.

5. Evaluations

(1) Evaluating Body

The Governing Board shall conduct evaluations, inviting external experts and others to participate. These evaluations shall be conducted with reference to results reports of self-inspections conducted by the PD, NEDO, etc. The Governing Board can host such evaluations for each field or task.

(2) Evaluation Period

- There shall be preliminary evaluations, year-end evaluations at the end of each fiscal year, and final evaluations.

・ After project conclusion, follow-up evaluations will be conducted as necessary after a certain amount of time has passed (generally three years).
・ In addition to the above, evaluations can also be conducted mid-fiscal year as necessary.

(3) Evaluation Parameters and Standards

Based on the General Guidelines for the Evaluation of Government Research and Development (R&D) Activities (Issued by the Prime Minister on December 21, 2016), and aiming to evaluate necessity, efficiency, effectiveness, and other such factors, evaluation parameters and standards shall be as follows below. Evaluations shall not simply judge accomplishment or failure of goals, but shall further include analysis of causes, proposals for ways to make improvements, etc.

1) Importance of the purpose; consistency with the objectives of the SIP system.
2) Adequacy of targets (especially outcome targets); degree of achievement of the progress schedule for achieving those targets.
3) Whether proper management is being conducted. In particular, whether there have been benefits due to collaboration between government agencies.
4) Quality of practical implementation and commercialization strategies; degree of achievement of those strategies.
(5) For final evaluations: anticipated effects or ripple effects. Whether post-project follow-up plans are appropriate and clearly established.

(4) Application of Evaluation Results

・ Preliminary evaluations shall be conducted concerning plans for the next and subsequent fiscal years, and applied to plans for the next and subsequent fiscal years.
・ Year-end evaluations shall be conducted concerning results up through the present fiscal year and plans for the next and subsequent fiscal years. These evaluations shall be applied to plans for the next and subsequent fiscal years.
・ Final evaluations shall be conducted concerning results up through the final fiscal year, and applied to post-project follow-up, etc.
・ Follow-up evaluations shall be conducted concerning the progress of the practical implementation and commercialization of tasks' results, and shall feature proposals for improvements, etc.

(5) Publishing Results

・ Evaluation results shall generally be made public.
・ Governing Boards that conduct evaluations shall not be made open to the public, due to the involvement of non-public research and development information, etc.

(6) Self-Inspections

1) Self-Inspection by Principal Investigator

The PD shall select the principal investigator who will perform a self-inspection. (In general, the principal researcher/research organization will be selected for each research item.)

The selected principal investigator shall apply "5.(3) Evaluation Parameters and Standards," inspect both achievements since the last evaluation and future plans, and not simply judge accomplishment or failure of goals, but shall further include analysis of causes, ways to make improvements, etc.

2) Self-Inspection by the PD

With reference to the self-inspection results of principal investigators as well as the opinions of third-parties and experts as necessary, the PD shall apply “5.(3) Evaluation Parameters and Standards”; inspect both the achievements and future plans of the PD, NEDO, and the principal investigators; and not simply judge accomplishment or failure of goals, but shall further include analysis of causes, ways to make improvements, etc. Drawing on the results of this self-inspection, the PD shall determine whether each principal investigator should continue their research and offer necessary advice to the principal investigators and others. In this way, this system should enable autonomous, self-directed improvements.

The PD, with the help of NEDO, shall create materials based on these results for the Governing Board.

3) Self-Inspection by the Management Agency

Self-inspections by NEDO shall consider topics such as whether administrative procedures are being properly conducted in terms of budget implementation.

6. Strategy for Commercialization

(1) Research and Development Promotion Toward Commercialization

After a common edge computing platform and low-energy IoT chips have been developed, they will undergo demonstration testing in manufacturing and other sectors experiencing workforce shortages. Successful results will demonstrate the effectiveness of the platform’s solution for promoting economic development and addressing social issues as well as help encourage the use of CPS. To this end, the R&D activities described under the three R&D subthemes will be promoted with a view toward commercializing project results. After selecting enterprises that will actually handle commercialization as partners for each subtheme, we will seek to receive between 10 to 20% of the total funds necessary for personnel, locations, equipment, etc. from the private sector. In particular, once the research stages have progressed and we have reached the social implementation and commercialization stage, we will advance while expanding investments from the private sector. This will allow us to swiftly advance commercialization in the industry.

- In the first R&D subtheme, cyberspace and the physical space will be unified with minimal labor by developing common platform technologies in order to resolve the various problems caused by deficiencies in IT professionals.
- In the second R&D subtheme, we have set as a goal social implementation via development and systemization of low-energy IoT devices and devices neighboring sensors, in which Japan has a competitive advantage.
- In the third R&D subtheme, we have set specific goals including increases in productivity through development of robots, etc. through advanced fusion of cyberspace and the physical space, when faced with representational social issues for which real-time capabilities and precision are crucial.

Additionally, with respect to the intelligent knowledge processing infrastructure integrating physical and virtual domains, by combining the results of existing PRISM and ImPACT, results concerning each government agency (three research organizations for artificial intelligence, etc.), and the results of the paired themes of “Big-Data and AI-Enabled Cyberspace Technologies,” and “Cyber Physical Security for IoT Society” among SIP issues in order to develop a more appealing platform, and by constructing systems to maintain and renew through consortia and the like, we can continuously promote new business opportunities and participation by the industry after the completion of the program, thereby maintaining and expanding the international competitive capability and financial growth of Japan.

(2) Measures for Dissemination

The project is designed to establish a common edge computing platform as a solution for integrating cyber and physical spaces with lower labor workload. It is expected that the IoT market will be revitalized by the entry of various industries that have missed business opportunities due to IT professional shortages.

As specific policies for technology dissemination,

- The first R&D subtheme will realize edge computing platform technology. Furthermore, in accordance with Japan's open and closed strategies, the common edge computing platform will be open to the public and maintained so that a variety of organizations, including small and medium-sized companies and venture businesses, will be able to develop IoT solutions. This will lower the barriers to entry into services that utilize advanced CPSs, and we can expect the provision of a diverse array of services that will resolve various social issues.
- The second R&D subtheme will resolve the issue of practical application found in low-energy IoT devices and innovative sensors, in which Japan has a strength, and by definitively connecting this to the first R&D subtheme, make social implementation through the third R&D subtheme possible, and promote new participation. Furthermore, this subtheme will support continuous deployment of Japan's scientific and technological capabilities, thereby making a large contribution to the acquisition of competitive ability at the international level.
- In the third R&D subtheme, by submitting examples of actual social implementation regarding specific and representational issues where real-time capabilities and precision are sought, we can broadly deploy the specific value of research details throughout society. By demonstrating the usage of results of digital data analyzed in a versatile and compounded manner with minimal labor, we can expect creation of new markets or promotion of participation.
- The physical space technology developed in this program will be disseminated by standardizing and opening the interface standards, thereby allowing many players in the industry to use them.
- The first and second R&D subthemes will be maintained and promoted through the establishment of consortia and the like that involve the industry through coordination with each government department, thereby contribute to the creation of new industries.

7. Other Important Items

(1) Basis Law, etc.

This program is implemented based on the following: Act for Establishment of the Cabinet Office (Act No. 89 of 1999) Art. 4-3(7)3; Basic Policy on the Cost of Promoting Innovation in Science and Technology (May 23, 2014; Council for Science, Technology and Innovation); Implementation Policy for the Cross-Ministerial Strategic Innovation Promotion Program (SIP) Second Phase (FY2017 Revised Budgetary Provision) (March 29, 2018; Council for Science, Technology and Innovation); Guidelines for the Cross-Ministerial Strategic Innovation Promotion Program (May 23, 2014; Council for Science, Technology and Innovation, Governing Board); and National Research and Development Agency Act on the New Energy and Industrial Technology Development Organization, Art. 15-1(2).

(2) Plan Flexibility

This plan shall be revised as required in the interest of maximizing and accelerating achievement of results.

(3) PD and Assigned Personnel

1. Program Director

Hideyuki Saso (since Apr.2018)

2. Sub Program Director

Kazuya Masu (since Apr.2018)

Hiroaki Nishi (Since July 2019)

Makoto Ishida (Since July 2019)

3. Director General for Science, Technology, and Innovation

Toshio Tonouchi (Since Oct. 2018)

4. Assigned Personnel

Susumu Sugano
(Since Apr.2018)

AkioTamagawa
(Since Apr.2019)

Attachment Material: Financial Plan and Estimates

FY2019 Total: 1,950,000,000 yen

(Funding Breakdown)

1. Confirmed distribution amount for the current fiscal year (including general management expenses and indirect expenses)
   1,750,000,000 yen
2. Amount of last fiscal year's adjustment expenses (*) to be distributed 200,000,000 yen
   (*The expenses set for adjustment in FY2019 while confirming the distribution for the previous fiscal year)
3. Amount carried over from last fiscal year 942,000,000 yen

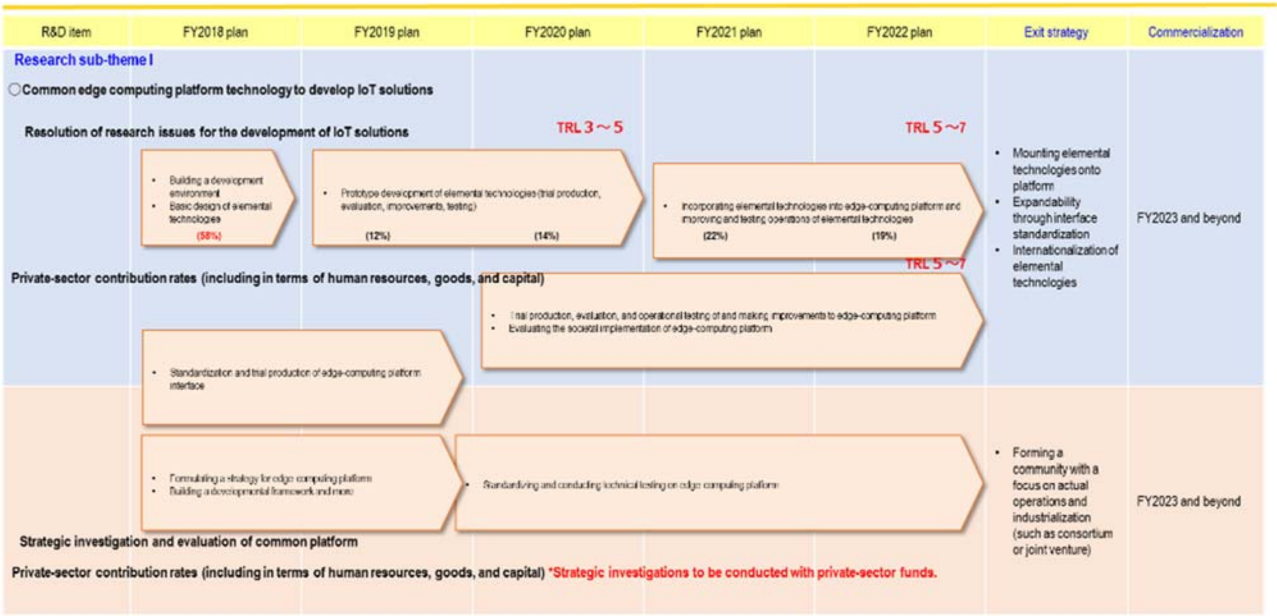
Total 1,950,000,000 yen (confirmed distribution + adjustment expenses)

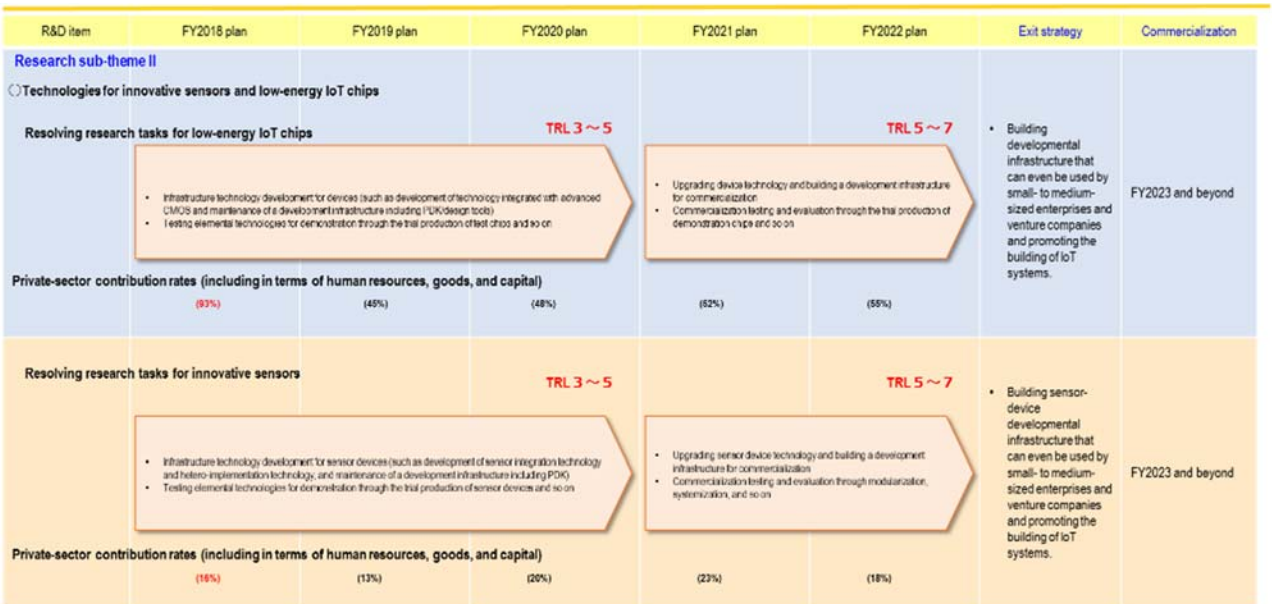
(Expenditures)

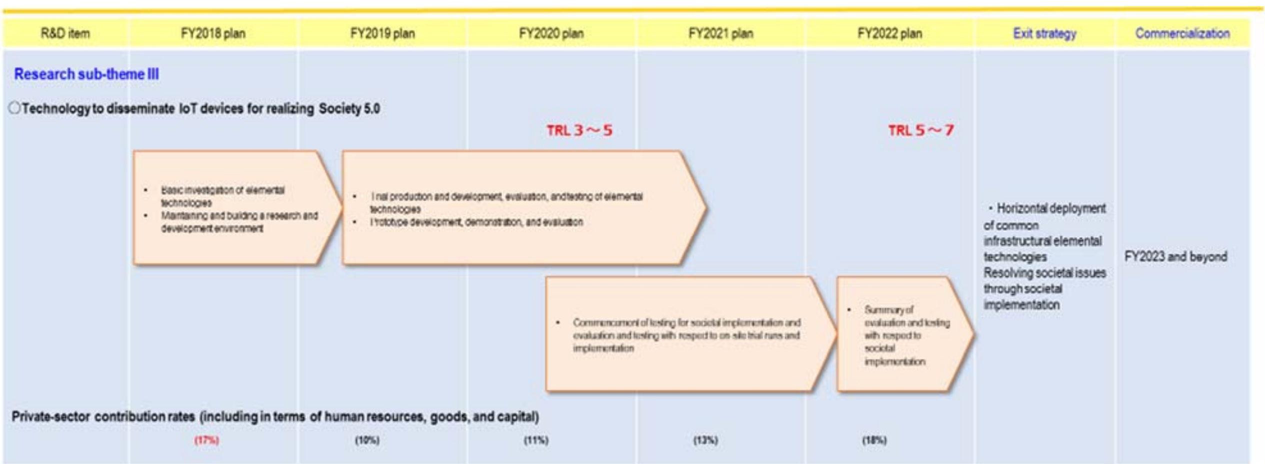
1. Research fees, etc. (includes general management expenses and indirect expenses) 2,523,000,000 yen
2. Business advancement expenses (personnel expenses, evaluation expenses, conference expenses, etc.)
   100,000,000 yen

Total 2,623,000,000 yen (confirmed distribution)

Schedule


R&D item
FY2018 plan
FY2019 plan
FY2020 plan
FY2021 plan
FY2022 plan
Exit strategy
Commercialization
Research sub-theme I
○Common edge computing platform technology to develop IoT solutions
Resolution of research issues for the development of IoT solutions
TRL 3～5
TRL 5～7
• Building a development environment
• Basic design of elemental technologies
(58%)
• Prototype development of elemental technologies (trial production, evaluation, improvements, testing)
(12%)
(14%)
• Incorporating elemental technologies into edge-computing platform and improving and testing operations of elemental technologies
(22%)
(19%)
TRL 5～7
Private-sector contribution rates (including in terms of human resources, goods, and capital)
• Trial production, evaluation, and operational testing of and making improvements to edge-computing platform
• Evaluating the societal implementation of edge-computing platform
• Standardization and trial production of edge-computing platform interface
• Mounting elemental technologies onto platform
• Expandability through interface standardization
• Internationalization of elemental technologies
FY2023 and beyond
• Formulating a strategy for edge computing platform
• Building a developmental framework and more
• Standardizing and conducting technical testing on edge computing platform
Strategic investigation and evaluation of common platform
Private-sector contribution rates (including in terms of human resources, goods, and capital) *Strategic investigations to be conducted with private-sector funds.
• Forming a community with a focus on actual operations and industrialization (such as consortium or joint venture)
FY2023 and beyond


R&D item
FY2018 plan
FY2019 plan
FY2020 plan
FY2021 plan
FY2022 plan
Exit strategy
Commercialization
Research sub-theme II
○Technologies for innovative sensors and low-energy IoT chips
Resolving research tasks for low-energy IoT chips
TRL 3～5
TRL 5～7
• Infrastructure technology development for devices (such as development of technology integrated with advanced CMOS and maintenance of a development infrastructure including PDK/design tools)
• Testing elemental technologies for demonstration through the trial production of test chips and so on
• Upgrading device technology and building a development infrastructure for commercialization
• Commercialization testing and evaluation through the trial production of demonstration chips and so on
• Building developmental infrastructure that can even be used by small- to medium-sized enterprises and venture companies and promoting the building of IoT systems.
FY2023 and beyond
Private-sector contribution rates (including in terms of human resources, goods, and capital)
(93%)
(45%)
(48%)
(52%)
(55%)
Resolving research tasks for innovative sensors
TRL 3～5
TRL 5～7
• Infrastructure technology development for sensor devices (such as development of sensor integration technology and hetero-implementation technology, and maintenance of a development infrastructure including PDK)
• Testing elemental technologies for demonstration through the trial production of sensor devices and so on
• Upgrading sensor device technology and building a development infrastructure for commercialization
• Commercialization testing and evaluation through modularization, systemization, and so on
• Building sensor-device developmental infrastructure that can even be used by small- to medium-sized enterprises and venture companies and promoting the building of IoT systems.
FY2023 and beyond
Private-sector contribution rates (including in terms of human resources, goods, and capital)
(16%)
(13%)
(20%)
(23%)
(18%)


R&D item
FY2018 plan
FY2019 plan
FY2020 plan
FY2021 plan
FY2022 plan
Exit strategy
Commercialization
Research sub-theme III
○Technology to disseminate IoT devices for realizing Society 5.0
TRL 3～5
TRL 5～7
• Basic investigation of elemental technologies
• Maintaining and building a research and development environment
• Trial production and development, evaluation, and testing of elemental technologies
• Prototype development, demonstration, and evaluation
• Commencement of testing for societal implementation and evaluation and testing with respect to on-site trial runs and implementation
• Summary of evaluation and testing with respect to societal implementation
• Horizontal deployment of common infrastructural elemental technologies Resolving societal issues through societal implementation
FY2023 and beyond
Private-sector contribution rates (including in terms of human resources, goods, and capital)
(17%)
(10%)
(11%)
(13%)
(18%)