JST Mirai-Program

*Mirai means “Future” in Japanese.

Japan Science and Technology Agency (JST) has started the JST Mirai-Program since FY2017. This program promotes research and development (R&D) toward “Proof of Concept (POC)” (the stage industry can decide whether they could make a business successful).

To achieve it, we set goals focusing on clear targets which realize economic and social impact and challenge technological difficulties. We also take advantage of outstanding outcomes of JST Strategic Basic Research Program and Grants-in-Aid for Scientific Research (KAKEN).

JST manage the program with flexibilities so that we can solve social issues through science and technology (S&T) Innovation through “Spiral Approach”.

Fig. Image of the Spiral Approach

Call for R&D Proposals (FY2017)

Application Guideline (Japanese only)

*English version (Provisional Translation) is coming soon on the website.

<Schedule>

*Japan time

Application Deadline:	Wed., July 19, 2017 at 12:00 noon
Notification of document screening results:	in August
Interview:	Middle of August - Late of September
Notification/announcement of selected Proposals:	in October (Tentative)
R&D project start:	Late October (Tentative)

<Themes>

Small start Type

"Realization of a Super Smart Society (Society 5.0)" area

R&D Supervisor (Program Officer; PO):

Akira MAEDA (Former Corporate Chief Engineer, Information & Communication Technology Business Division, Hitachi Ltd.)

Theme:

- Building a service platform for creation of new services by collaboration and cooperation of various components

"Realization of a Sustainable Society" area

R&D Supervisor (PO):

Hideyo KUNIEDA (Council member, Nagoya University)

Themes:

- Innovation in manufacturing for new process of sustainable resource recycle
- Improving intellectual capability to enhance "a Socially Active Life" for overcoming the reducing labor force

"Realization of the most Safe and Secure Society in the world" area

R&D Supervisor (PO):

Ken-ichi TANAKA (Executive Fellow, Mitsubishi Electric Corporation)

Themes:

- Development of the crisis navigator for individuals
- Creation of "humane service" industries

"Realization of a Low Carbon Society, a global issue" area

R&D Supervisor (PO):

Kazuhito HASHIMOTO (President, National Institute for Materials Science)

Theme:

- Realization of a low carbon society through game changing technologies

Large scale Type

R&D Supervisor (PO):

Yoshio HAYASHI (Program Director, JST)

Themes:

- Laser-plasma acceleration technologies leading to innovative downsizing and high energy of particle accelerators
- High-temperature superconducting wire joint technologies leading to innovative reduction of energy loss
- Quantum inertial sensor technologies leading to innovative high precision and downsizing of self-localization units

Small start Type : Prioritized Themes FY2017

5.1.1 “Realization of a super smart society (Society 5.0)” area

R& D Supervisor (Program Officer: PO):
Akira MAEDA
(Former Corporate Chief Engineer, Information & Communication Technology Business Division, Hitachi Ltd.)

I Goal of the “Realization of a super smart society (Society 5.0)” area

This area assumes that a “super smart society” (synonymous to Society 5.0) is considered a “society in which things of the real society are incorporated with intelligent software for sophisticated functions (making it smart), and things cooperate to automate societal systems for high efficiency as well as facilitate new functions and services.” The question “how is it different from ”a smart society” or “an information society” referred to as in Society 4.0” may be answered as following: “assuming information technologies is for sophisticated information and data processing in cyber space, a super smart society incorporates intelligence of information technologies into a physical entity, such as electrical power systems, transportation systems, service robots, and similar entities, for them to interact for the expansion of the range of automation and autonomy as the whole system, and possesses a mechanism for sustainable creation of new services and businesses.

In other words, it is believed that in a “super smart society” or “Society 5.0”, cyber space cannot be separated from the real world; software is incorporated into things in the real world and the existing societal systems collaborate by IoT, integrated with real world (hardware) and software to constitute a system or “system of systems,”.

Based on this assumption, “system coordination,” “system of systems,” and “distributed coordination” that emphasize collaboration of the whole system were extracted from an analysis of about 400 offered proposals and interviews with 39 experts. Based on the above, a basis for flexible and dynamic collaboration and cooperation of functions implemented in various systems were defined as “service platform” to be set up as a the prioritized theme for recruitment of research proposal. A workshop was held for experts to dig into specific contents of the service platform and contents of research. At the workshop, the service platform was reconfirmed to be important, and “building a service platform that allows collaboration and cooperation of various components for creation of new services” was set up as a prioritized theme for recruitment of research proposal.

II Prioritized theme

Building a service platform that allows collaboration and cooperation of various components for creation of new services

(1) About the theme

To accelerate the realization of a ”super smart society” , this prioritized theme aims to build a “service platform”; a mechanism that allows the creation of new services by extract “functions” possessed by various instruments connected to networks by IoT, and the “functions” of existing and new systems are turned as components and combined for collaboration and cooperation. Specifically, functions* at various layers, including controls of things in the real world, are turned as components to provide an open API to build a mechanism for the collaboration and cooperation of various components. This allows for API to be accessed, utilize, and combine functions of components to realize new functions and services. Moreover, techniques, including artificial intelligence, automate collaboration of functions to develop technologies that allow flexible and dynamic collaboration and cooperation, including negotiation and mediation functions, among systems and instruments.

In addition, this prioritized theme for recruitment of research proposal keeps in mind new values and services to be realized through building the platform in carrying out research while depicting a scenario toward the goal.

At present, the 5th Science and Technology Basic Plan of the Cabinet Office sets out 11 systems to realize a “super smart society” (Society 5.0); these systems are, among others, smart manufacturing system, energy value chain system, and high degree transportation system. The Plan also implements policies to promote individual systems. In addition, to support the 11 systems, approaches have already begun for base technologies, including AI, big data processing technologies, and database construction. However, adequate approaches have not yet been taken for a service platform mechanism by functional cooperation; these approaches include continued supplies of optimal services in flexible combinations of existing/new systems or instruments. The mechanism has not yet been realized.

To promote the prioritized theme for recruitment of research proposal and to realize a service platform for collaboration and cooperation of various functions allow the planning of automation, autonomy, and efficiency among a wide range of existing/new systems, and create a new system, a new service, a new business, a new innovation other than the 11 systems. A super smart society will be realized through research and development of API and component preparation techniques, collaboration and cooperation techniques for component combination, techniques to secure real time actions by modelling simulation, security techniques, and architectural design techniques.

*functions at various layers:

For example, technologies from transportation system to automated driving layer down to individual IoT sensors. Functions include not only information exchange in cyber space but also systems and controlling things in the real world.

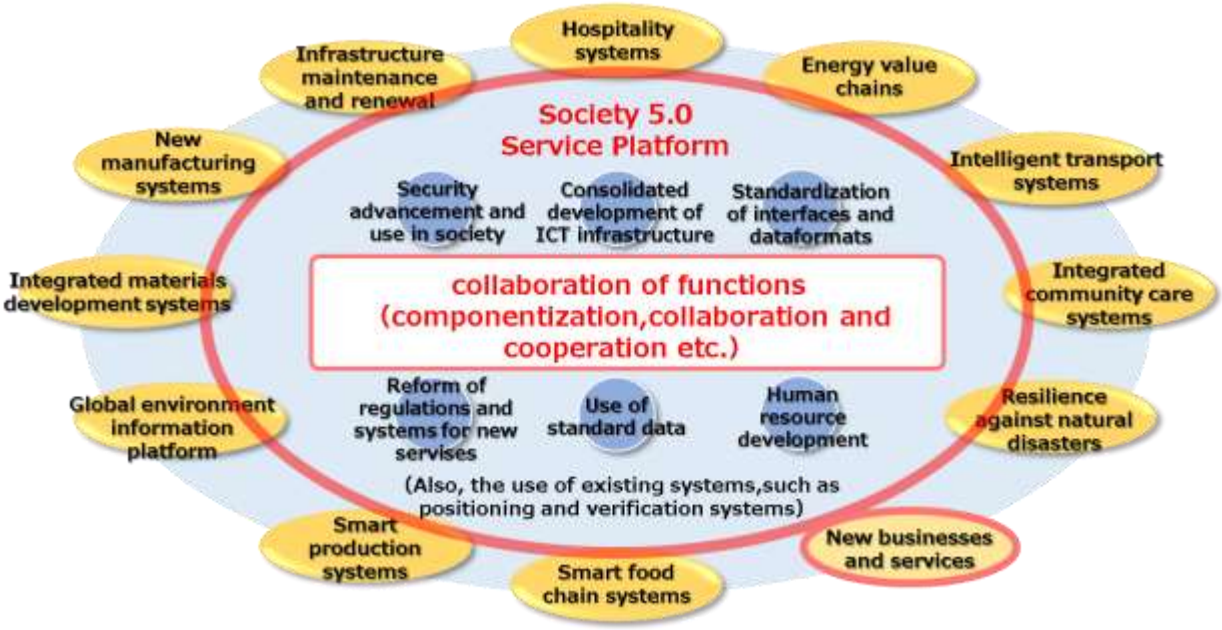

Fig. Primary target of this prioritized theme (red frame,red word)

(2) Policies of the R&D Supervisor for proposal selection and R&D management

① Background

Recent rapid progress in information and communication technologies has connected humans to things, or things to things, in many fields, including manufacturing, transportation, finance, and medicine, to improve efficiency of existing services and create new businesses and services. The conventional society for "sophisticated information processing in cyber space" has been made super smart to be a society in which "information technologies incorporate intelligence into things, and the intelligence interacts to create new values," This movement has been accepted by society and people to stimulate an emergence of new services, such as Uber and Airbnb, which are changing values and lifestyle, including sharing of economy that promotes changes from possession to utilization.

The Cabinet Office is promoting research and development for sophisticated individual systems by national policies and base technologies, including AI and big data and database, toward the realization of a super smart society. However, platform technologies, which connect between cyber space and things in the real world and go beyond data collaboration to allow collaboration and cooperation among systems and instruments, have not been developed adequately. Moreover, private companies have promoted research and development in IoT and AI, and begun approaches to cross-sectional data collaboration. However, technologies have not been developed adequately for API and component preparation for inter-systems and collaboration and cooperation among instruments.

This prioritized theme forrecruitment of research proposal aims to build a service platform that serves as a basis for new service creation to contribute to the realization of a super smart society and accelerated creation of new values.

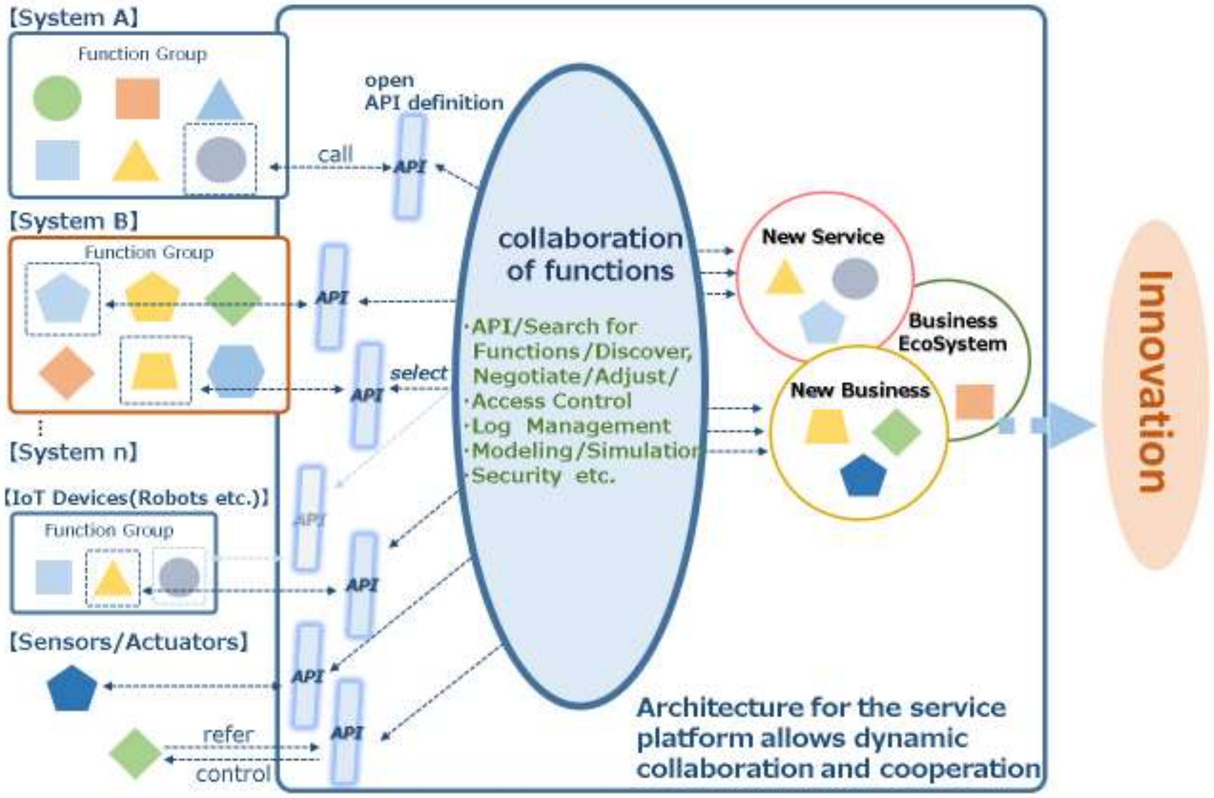

Fig. collaboration of function by a service platform

② **Policiesof proposals selection**

(Regarding the proposal scenario)

As a service platform, proposals are recruited for a system technology that allows flexible and dynamic collaboration of functions among systems and instruments.

Every proposal must include a specific scenario for how functional collaboration among systems and instruments creates values (societal and economic). Please depict a scenario for implementation in a society as much as possible, in addition to a research and development plan. In the case of a proposal for the development of a common base technology for various services, for example, please depict a specific partner of collaboration, such as an electrical power and a transportation system, and show how societal and economic impacts may be created. If the impacts are not clear, research contents may include a FS to clarify the impacts.

Moreover, a proposal of an element technology is acceptable if its value is clearly shown in the whole system. In such case, please show clearly implemented contents of the FS for ideas of the scenario.

(Regarding technologies)

We welcome proposals for the development of the following new technologies necessary for building a service platform based on specific use cases or scenarios:

- Technologies for turning sub-functions to API or components while utilizing existing systems as they are

- Technologies that secure stability and reliability, in addition to realizing functions as a system through the collaboration and cooperation of many various components that are different in size and operational policies
- Technologies that secure traceability, including information on records of API call outs
- Technologies that secure real-time actions and reliability by modelling and simulation, to realize functions for controlling things and systems turned to API in real space
- Security technologies common to the above technologies, and service platform technologies for security
- Architectural design for the whole platform on the assumption of collaboration and cooperation

(Regarding team composition)

It is not necessary to form a team that covers all ideas at the beginning. It is acceptable to propose building a team during FS.

③ Policies to promote research and development

FS is performed during preparation of a full-scale research. In principle, FS period is one and a half years (until the end of FY 2018).

Specifically, an approach is supposed to be conducted to the following studies in FS:

- Clarify research achievements and a scenario for implementation in a society, and verify the impacts on societal and economic impacts
- Verify technological feasibility, and specify technological development targets and a development scenario
- Proceed to form an effective team, including private companies, while keeping an eye on implementation in a society

Moreover, in transition from FS to a full-scale research, it is assumed that not only selection and concentration but also bold system changes, including sub-team reorganization within a project team, may take place. An earlier transition to a full-scale research (research and development proposal) is also possible depending on research progress.

Upon selection of the individual proposal in the prioritized theme for recruitment of research proposal, a whole platform architecture, incorporating tracking, value redistribution, and a societal system, will be considered. The architecture of a whole platform may be applied as a project. If not adopted, however, the research and development supervisor will manage the study of a platform architecture. Promotion of participation, coordination, and collaboration activities in an international collaboration frame will also be reviewed in this theme.

④ **R&D Period and Budgets**

The R&D budgets amounts to JPY 10 to 30 million (including indirect expenses) throughout the FS period (one and a half years in principle). Budget will be allocated flexibly depending upon research contents. When it moves up to a full-scale research, the budget is increased to a maximum of JPY 400 million (including indirect expenses) for carrying out research toward proof of concept (POC).

5.1.2 “Realization of a Sustainable Society” area

R&D Supervisor (Program Officer: PO):
Hideyo KUNIEDA
(Council member, Nagoya University)

I Goals of “Realization of a Sustainable Society” area

The “Quest of a sustainable society” is an ultimate goal for not only Japan but also the whole humankind.

The direction of development has shifted globally from mere economic development to sustainable societies. This direction is expressed in the Sustainable Development Goals (SDGs) of the United Nations. We now face the necessity to increase the quality of life and at the same time realize sustainable development of society.

Attention to the present situation of Japan shows that the stagnant economy has persisted for more than 20 years in the changing global environment characterized by climate change; further, globalization has weakened competitiveness in many industries, including manufacturing, in which Japan exceled. Moreover, population decrease has begun in the aging society with smaller numbers of children proceeding faster than other countries of the world to decrease its productive labor population and increase the number of elderlies who need support by society. It is fact that the sustainability of the life in Japan becomes in crtical situation.

This research area aims to adapt flexibly to these changes in “environment,” “society,” and “economy” to realize a high quality and mature society by maximum utilization of science and technology.

Based on proposed themes from the society (about 700 proposals related to this area) and discussions with experts in various fields, various research fields and approaches are reviewd which may creat values and contribute to the goals in our area. Then, the prioritized themes are explored for the maximum benefits to future generations specifically in regard to the goal “improving the natural environment (ecological services) and the well-being of people toward the realization of a sustainable society.”

A “symbiosis with natural environment” and “responding to super aging and decreasing population” are two view points of the review. “Innovation in manufacturing for new process of sustainable resource recycle” and “Improving intellectual capability to enhance a “Societally Active life”[1] for overcoming the reducing laborer force,” were chosen finally as the prioritized themes for FY 2017.

[1] Societically active life means lifetime during which an individual can stand on herself or himself to participate actively in societical activities, including a job. It is different from “biological longevity” or “healthy longevity,” which means the ability to live a daily life without restriction, owing to health problems.

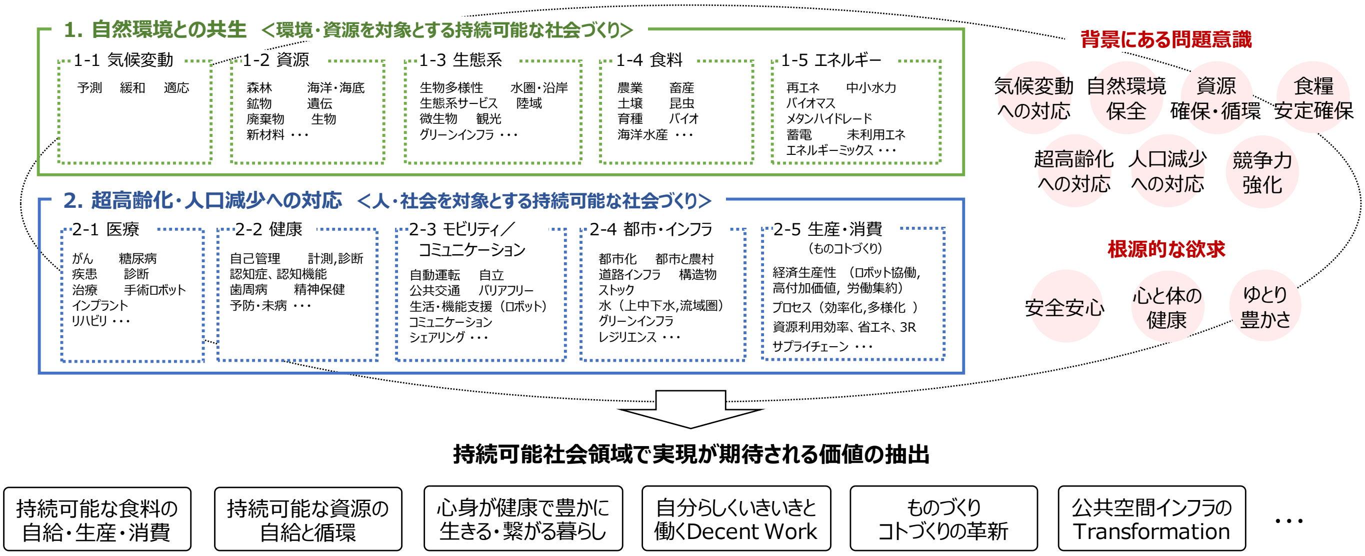

Fig.1 The values expected to be created in this area

II Prioritized Themes

1. Innovation in manufacturing for new process of sustainable resource recycle

(1) About the theme

This prioritized theme aims to recover industrial competitiveness in changing societies, and to promote sustainable utilization of natural resources, especially mineral (metal and nonmetal) resources and fossil resources that are becoming short globally soon. New manufacturing processes are expected by carrying out research and developments(R&D) on the selection of materials and on the design, production, and separation of products for optimizing the whole material cycle from the design, production, use, separation, and to retrieval of material for a great leap in resource utilization efficiency.

Many products have been designed for the best initial performance and price in the society of mass production and consumption, assuming disposal at the end of the product life. However, it becomes strongly demanded to shift to "recycle-oriented manufacturing" for highly efficient utilization of resources in response to tight supply of global resources, which will surely come in near future.

When looking at the world, one finds that SDGs (Sustainable Development Goals) of the United Nations include "Goal 12. Ensure sustainable consumption and production patterns." Responses from the society and industries are requested urgently. In fact, Europe has a concept "CE: Circular Economy," which is spreading in EU countries to ask the cost of recovery and retrieval of material to be charged on manufacturers. Because the cost is added to the price of the product, highly efficient recycling utilization of resources becomes major area of the manufacturing competitiveness of industries.

When looking at approaches to effective utilization of resources in Japan, one finds mostly individual and independent R&D's for reducing the use volume of resources (rare metals in particular) and recovery of resources from used products. Moreover, retrieval is still major process than reuse with/without refurbish (specifically upgradability[2] utilization), which provides us with higher efficiency of resource recycle. In addition, frequently observed examples of retrieval are "down cycle," which is material treatment for lower quality products. Therefore, it is urgent to carry out fundamental level R&D, of the processes in production, use, separation, reuse and retrieval to convert down cycle to upcycle (retrieval of material with higher quality), in order to make a leap in resource recycle efficiency.

In some area, an effective utilization of resources results from technology progress and societal demands, and it spreads from iron to rare metal and plastics. The cycle is changing slowly from conventional utilization(retrieval) to more efficient reuse and longer life of use. For more highly efficient resource utilization, this program promotes R&D on advanced individual technologies and their integration to create a totally new resource recycle loop from "design, production, separation and reuse".

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[2] Upgradability: Capability of being improved in functionality and performance not by the reintroduction of the entire product but by the replacement of some components or system.

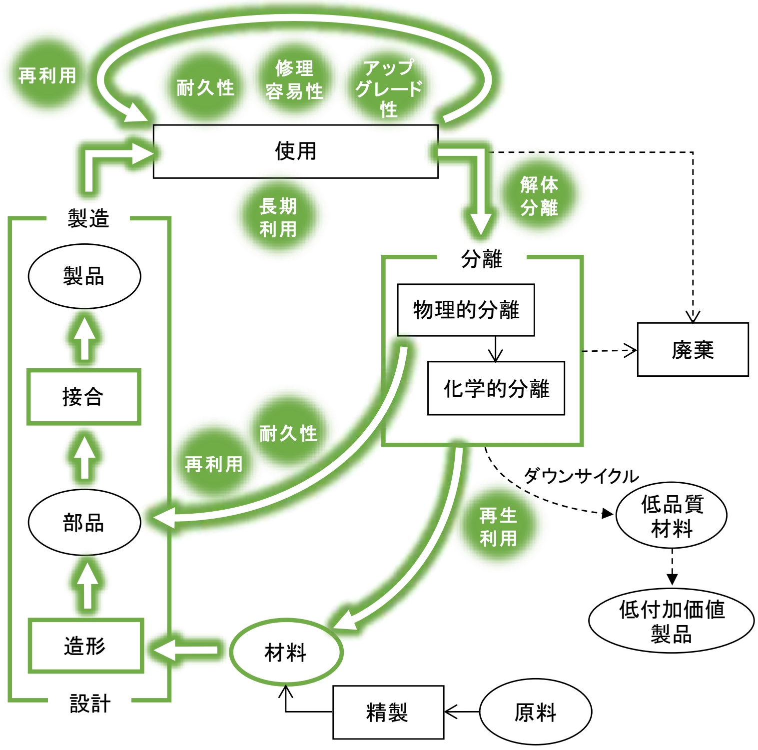

Fig.2 New process of sustainable resource recycle model

(2) Policies of the R&D Supervisor for proposal selection and R&D management

① Policies for proposal selection

For this prioritized theme, a series of R&D will be promoted for an efficient cycle of resources in a whole cycle of design, production, and separation of materials.

Described below are major requirements of a full-scale research that are not necessarily planned in all FS proposals. However, it is necessary in FS proposals to include “new cycle for resources and products” and “original and challenging solutions for bottlenecks.” (Please confirm in the following description.) Please note that requirements left unclarified in your proposal need to be clarified during the FS stage before moving to the full-scale research.

(Contents of R&D)

A design is necessary; it should include the plan to integrate and optimize whole recycle system, with processes of design, production, and separation for improving resource efficiency, by a new cycle of resources and products through conversion from downcycle to recycle and upcycle, and from retrieval to reuse and long life use. A scientific and technological bottleneck needs to be set out; such bottleneck provides a high impact when solved, and its highly original and challenging solutions are considered as major elements of R&D. Following i-iii are examples of possible approaches.

Although some R&D studies may depend on existing technologies, R&D carried out only on the extension of such existing technologies will not be supported by this program. For the creation of high impact effects on society and economy, proposals are expected to include R&D based on basic scientific studies and aiming to develop innovative technologies with a big leap.

i. Advanced material design and development that facilitate easy retrieval

What is conceived here are the design and R&D of a material to easily process used material to equivalent or better matrial in quality than the original one and then ultimate efficency of recycle will be achieved.

ii. R&D on molding and coating techniques that improve tolerance substantially

R&D for innovative molding and coating techniques that allow substantial extension of product lifetime

iii. R&D of bonding techniques that allow ready for physical separation

R&D on innovative technologies for easy separation while meeting such performance as bonding strength, tight sealing, and environmental tolerance

Specifically, the following images of proposal are conceivable:

- Concerning a conventional down-cycle manufacturing process for the retrieval after crushing, a proposal may aim to research and develop advanced technologies related to material development and production for easy retrieval by innovative bonding techniques for easy physical separation, so that different material can be retrieved from different pieces. Such an advanced bonding technique allows to obtain materials of equivalent to or better than the original material in quality, as well as to decrease the quantity of waste material.
- A proposal may aim to develop advanced technologies of molding and coating to extend product lifetime and part lifetime substantially, which have been rather short, and to develop bonding techniques for easy physical parts separation to achieve improvement in repairing and upgrading through the reuse with replacement of parts, shifting from conventional retrieval to reuse concerning major cycles.

Inclusion of R&D on important measuring techniques themselves is conceivable for the promotion of R&D on the observation of critical microscopic structure of bonding surface and nano structure of material surface.

Standardization plans in collaboration with a wide range of industries for the maximization of recycling efficiency, including standardization of parts for sharing, will also be given priorities.

R&D of production facilities at the actual production line will not be supported.

(Assumed applications)

R&D approaches are required to be based on clear targets for needs of industries and to create societical and economic impacts on resource recycles. Therefore, it is necessary to see a specific (group of) product as an example of application of R&D achievements. At the same time, because this program expects wider imapcts of achievements, it is also extremely important to aim to develop technologies applicable to a wider range of products.

(R&D system)

Creating achievements attractive for industries is necessary for developed technologies to be put to practical use, and for a resource and product recycle to actually function. Therefore, participation by industries is preferable in stages proceeding to a full-scale research.

(Contents required in FS proposal)

In propsal form 2, a clear idea has to be presented for a vision of a new cycle of resources and products and for an original solution of a bottleneck.

In proposal form 3, please clearly describe contents of R&D to be performed during the FS period and targets to be achieved by the end of a FS term, as well as perspectives of specific issues that required to proceed to the full-scale research but not clear yet at the begining of the FS phase.

For example, a proposal with the following contents is expected:

- An innovative technology at a development stage shall be verified for a scientific principle and subjected to manifestation of scientific and technological risks toward next step of full-scale research.
- A proposal will be made for the optimization scheme of resource and product cycle at a stage of an idea, to specify the idea of a cycle to maximize societical and industrial impacts during a FS stage and compose an optimal team involving academia and industries if possible.
- A proposal will be made concerning applications to (groups of) products to set an example of achievement application with big impacts, as well as to consider a collaboration system with industries during the FS.

② Policies for R&D management

Because adoption and application to society and the industries can be predicted to proceed rapidly by the projects on this prioritized theme, transition to a full-scale research shall be considered positively even during a FS stage, when large impacts of a bottleneck solution on society and the industries are foreseen, If the R&D Supervisor recognize that it is necessary to recompose for the maximization of societical and economic impacts, a number of R&D programs may be merged to an integrated team.

③ R&D Period and Budgets

For the research proposal submitted in FY 2017, please plan within a maximum period of two years. (However, time spent in FY 2017 is calculated to be one year regardless of when R&D starts.) Please make a plan with a maximum total budget of 40 million JPY (including indirect expenses) for the whole FS period.

For a full-scale research, please plan within five years with a maximum total budget of 2 billion JPY (including indirect expenses).

2. Improving intellectual capability to enhance a "Societally Active life"[3] for overcoming the reducing laborer force

(1) About the theme

In the era of super aging and decreasing population of Japan, counter measures are needed urgently against for the decrease of labor population and the increase of welfare cost, which may weaken the industrial competitiveness and the country itself. In order to activate an untapped labor force, these phenomena require new approaches, such as an enhancement of "societically active life," which allows various people, including the elderlies, to play more roles in society.

Examining elderly people, for example, shows that 70% of them intend to work even after reaching the retirement age. However, decreased physical and intellectual functions are said to be a factor reducing their morale and opportunities. R&D's in academia and industries to mainly support physical functions have made progress in these days. However, the enhancement of intellectual functions has not been explored so much yet.

Moreover, changing to a new job requires to get new skills. In addition, the tacit knowledge, such as special technique or expert skills, will be lsot if they are not transfred to the next generations.

As described above, the creation of labor population and maintenance and expansion of intellectual productivity are urgent issues to be addressed immediately to respond to the super aging and decreasing population. Hence, this prioritized theme aims to retrieve diverse untapped labor force and then to strengthen industrial competitiveness, by createing a system that allows science and technology to utilize "intelligence" for personal and public use at a proper timing and place.

Moreover, Looking at the world, one finds that SDGs (Sustainable Development Goals) of the United Nations include "Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all," as many countries face similar situations. Solving probelms for participation in society, including labor, and improving the Quality of Life (QoL) and Quality of Work (QoW), have become common goals of the world.

Services related to supporting "intellectual activity" provided by the system, which this prioritized theme aims to create, are expected to improve participation in society by various people, including the elderlies, to increase opportunities for employment, and to improve the quality of life and work. It is believed to enrich the mind of each person through connection to society and people. In addition, a future society in which humans and machinery are predicted to collaborate is believed to provide an environment in which people are able to keep their humanity. For that purpose, this prioritized theme aims to realize a society in which everyone has meaning in living to give full play of one's role in the society for a long time.

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[3] Societically active longevity means longevity during which an individual can stand on herself or himself to participate actively in societical activities, including a job. It is different from "biological longevity" or "healthy longevity," which means the ability to live a daily life without restriction, owing to health problems.

(2) Policies of the R&D Supervisor for proposal selection and R&D management

① Policies for proposal selection

This prioritized theme requires R&D of a system for supporting human intellectual activities with a clear object of the creation of new labor force and intellectual productivity.

A clear vision of the services to be provided has to be demonstrated beyond the development of individual technologies. Specifically, the followings are the examples expected to be newly possible:

i. Maintenance and improvement of personal intellectual activities

In a series of intellectual activities, including labor of an individual, there are cases in which a smooth intellectual activity may be disturbed, owing to a decreased level of an intellectual function, such as inability to recall a memory (a simple lapse of memory) or inability to perform something that could be completed in the past. The acquisition or improvement of a new skill by an individual tends to become difficult for elderlies. When such incidents happen frequently, it not only becomes an obstacle for actual work but also decreases the willingness to work or participate in society, a concern that further alienates her or him from society.

Databases based on an accumulated general information, such as dictionaries or internet search, have been mainly utilized to support memory retrieval[4] by using information technologies in the past.

Meanwhile, R&D has not advanced much for a system to accumulate personal information to serve the memories one wishes to retrieve in a timely manner. Once a support system to maintenane and improve such intellectual performance is established, it will become possible to improve the intellectual productivity of an individual and extend her or his “societical active life.” In addition, increasing number of individuals, who play their role actively for a long time, are expected to lead to the decrease of the societical burden, such as medical expenses and societical welfare costs.

ii. Support system for getting new jobs

Certain levels of knowledge or experience are required for jobs, such as operation of a processing machine or an OA equipment. An obstacle of learning skills of a new job for young people, who have no experience, may prevent unskilled laborers from employment. Moreover, as introduction of AI proceeds, there may be cases in which individuals are forced to change jobs or positions owing to the change of societical systems. Certain individuals may find it difficult to respond to the changes.

Many of the jobs mentioned above can be described in a manual. However, it is difficult to perform the job by referring to the manual alone. Many jobs require a process for acquiring intellectual and technical knowleges by oneself through practicum, technique acquisition training, or training with a simulator, which provide a person with a process to learn knowledgs and skills by herself or himself.

A system to support individuals is expected for gaining intellectual and technical knowledges effectively, based on the understanding of the mechanisms to learn

[4] Retrieval refers to recalling things or related images experienced in the past.

intellectual and technical knowledgs. Such a system allows possibilities to retrieve new labor force which was not visible in the past and to promote labor mobility to respond to the change of labor distribution in the future, and then to improve the intellectual productivity of whole society.

iii. Transfer of high-level skills

The so-called “professionals,” ”skilled workers,” and ”master artisans” possess a hunch or a knack, which is a high-level intellectual knowledge, technique, action, and viewpoint and cannot be imitated easily. The difficulty to tansfer is due to the fact that the key controling points of the process have not been well understood and not been crystalized to tranferable knowledge. If such knowledge and techinique can be understoood and reproduced by the basic measuring technology, it becomes possible to transfer and share the original high level techinique, which has belonged only to the master. Sharing the technique by the public improves dramatically productivity and commpetitiveness of the society. Examining the mechanism of such a high-level intellectual activity is believed to make it possible to build a base for creating values of society, such as skills and culture that people of a future society transfer.

The above descriptions are merely simple examples. A proposal is not restricted to them. We expect a variety of proposals based on your original ideas.

Target technology fields range from basic research, to high-level application research of information technology. Collaboration is also expected between various research fields, including cognitive science, psychology, and neuroscience.

Respecting the will of an individual (freedom of choice, agreement and its revoking and so on), consideration for privacy, and examinations of physical and psychological influence, ethical issues, and issues of a societical system are essential in accessing and utilizing memories and experiences of individuals. Therefore, a clear scenario for solving ELSI[5] issues is necessary at the developmental stage of individual technology.

In addition, studies on robustness and reliability of a system, and avoiding disperity such as a digital divide, are necessary to be started from the beginning for societical application of research results. Therefore, approaches, such as inclusive design (exclude nobody and include everyone), and thinking design together (Co-design) and thereafter are considered useful.

To meet the rapid changes in relevant science and technology and a societical situation, this prioritized theme expects proposers to survey adequately domestic and international trends, and to have dialogues with users, and to organize a team for flexible reviews and R&D plan.

As this prioritized theme includes many immature level of R&D, relatively small-scale yet challenging research proposals are welcomed as search studies and then they could be merged and integrated with other search studies for the next step of a full-scale research.

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[5] Ethical, legal, and social issues manifest at the interface with society when conducting research.

The following type of R&D projects are not the target ones of this theme:

- Those aiming to support physical activities only
- Approaches including direct action to the “brain” or the “nerves”
- Those including “mind (feeling)” as a subject

② Policies for R&D management

Societical trends and rapid progress in science and technology in Japan and overseas are to change the environment and requirements of this prioritized theme. Therefore, we plan to collaborate with related projects in Japan and to arrange collaborations among projects in this prioritized theme, and to share information to deepen discussions with a wide range of domestic and overseas parties openly and continuously.

We may also instruct R&D projects to merge or changes of R&D plans (including team structure or budget), if necessary. In addition, we will accelerate movement to a full-scale research, if the R&D Supervisor judges it is adequate even before completion of a FS term.

③ R&D Period and Budgets

For R&D projects starting in FY 2017, please propose a plan based on a maximum FS period of three years (time spent in FY 2017 is calculated to be one year regardless of when R&D starts) and a total budget for a whole FS period of about 40 to 60 million JPY (including indirect expenses).

A full-scale research must be completed within a maximum of five years and a maximum total research budget of 2 billion JPY (including indirect expenses).

5.1.3 “Realization of the most Safe and Secure Society in the world” area

R&D Supervisor (Program Officer; PO):
Ken-ichi TANAKA
(Executive Fellow, Mitsubishi Electric Corporation)

I Goal of “Realization of the most safe and secure society in the world” area

Our society is changing every day.

The Internet service has dramatically improved communication methods, so that people can now easily communicate with everyone all over the world. However, the risks of cyber-attack and terrorism are growing, therefore security must be more secure. The essential things for human lives, such as air, water and foods, are needed to be supplied for our daily lives concurrently with the measures against natural disasters such as earthquake, guerilla storm, and typhoon. Since Japan currently faces an aging society, more than one fourth of population is aged over 65. It is an urgent task to build a society which elderly people can live actively and heartfully. With these social changes, we are always needed to explore how to improve “Safety and Security” in our society.

When considering “Safety and Security”, we must keep in mind that “Security” is based on our individual sense, so that scientific data cannot ensure “feelings of security” in people's lives; however, “Safety” can be evaluated by scientific indicators. The evidence of safety does not necessarily mean the indicator of “sense of security”.

Based on the above, the aim of this research area is to realize a society in which everyone can feel secured, by providing people with “Safety and Security”.

To decide a prioritized theme of call for research proposal in FY 2017, we interviewed experts in various fields and analyzed proposed themes. (There were about 500 proposals, which were related to the area of safety and security.) In consequence, two themes have developed; (1) Development of the crisis navigator for individuals-- for safety and security in emergency, (2) Creation of humane* service industries-- for people’s security in their daily life.

*Humane means merciful, sympathetic, and making a person noble.

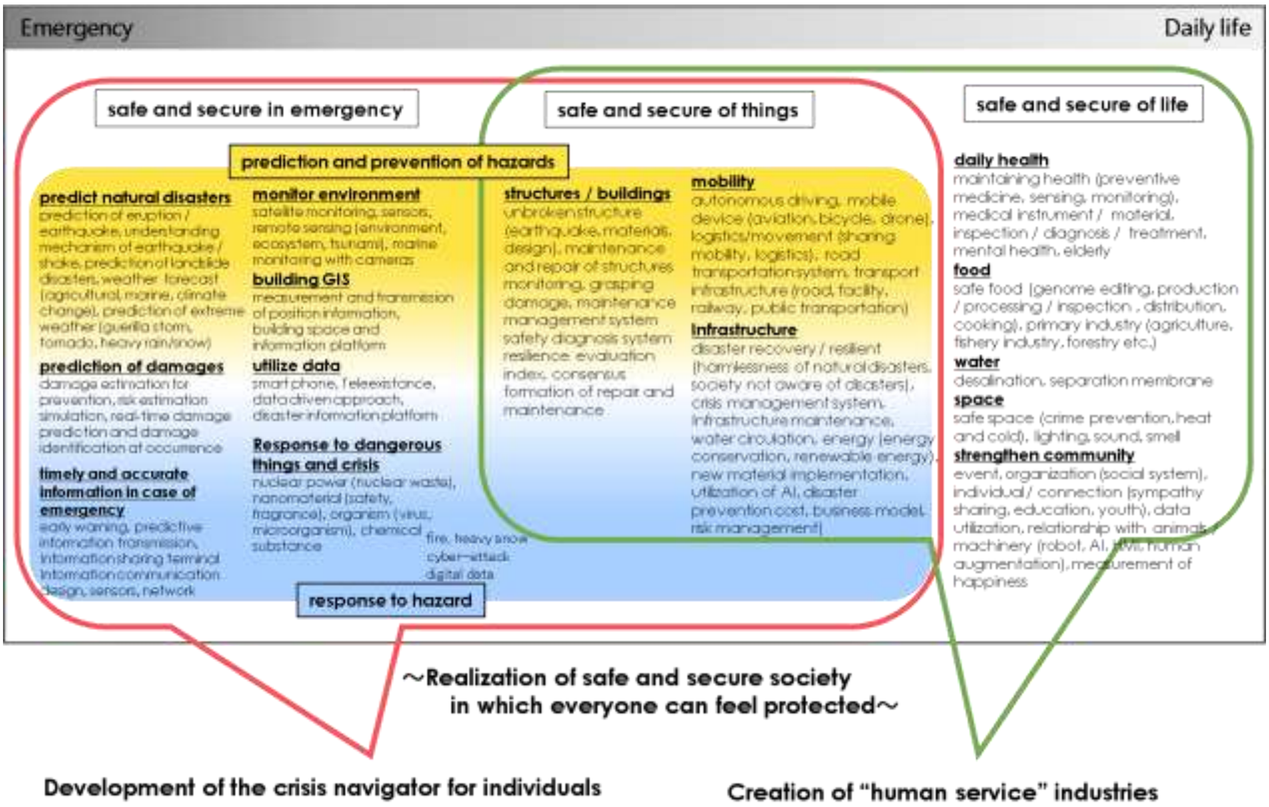

Fig.1 Structure of the values expected to be created in this area

II　Prioritized themes

1. Development of the crisis navigator for individuals

(1) About the Theme

There are three types of hazard approaches such are prediction, prevention, and response phases. We focus on "response phase". Our goals are to improve the accuracy of decisions by organizations using technologies and to develop "navigator" which delivers options of actions to individuals.

The word "Hazard" indicates not only natural disasters but also every dangerous factors that cause unexpected emergency such as accidents, incidents, and cyber-attacks. Our society is increasingly becoming more diversified and complex, for example, accelerating the globalization and expanding of the internet makes us easy to access to cyber-space. Under such circumstances, hazard and risk would not be eliminated naturally. To consider scientific approaches to eliminate the hazard or minimize damage, we must recognize that we are surrounded with various risks.

The approaches can be grouped into three phases: prediction of hazard (sensing hazard), prevention (preparing for damage), and response (responding to crisis to overcome it quickly). In the phase of those, prediction and prevention of hazard, have recently been upgraded by technologies. On the other hand, the response phase still tends to depend heavily upon "human decision." We consider a basic process of the response phase as follows; 1)people take action relying on decision of organizations[6] 2)people take action to secure her or his own safety(escaping and hiding) or to secure safety of society(helping others, protecting something). Our goal is to establish high-level technology which supports these processes.

Also we aim at developing a "navigator" to support decision of organizations and action of individuals.

[6] An organization means an entity that is responsible for securing safety of relevant individuals (members, users at the time). For example, the government, a municipality, a large-scale facility, an event manager, a building manager, a private company, and similar entities.

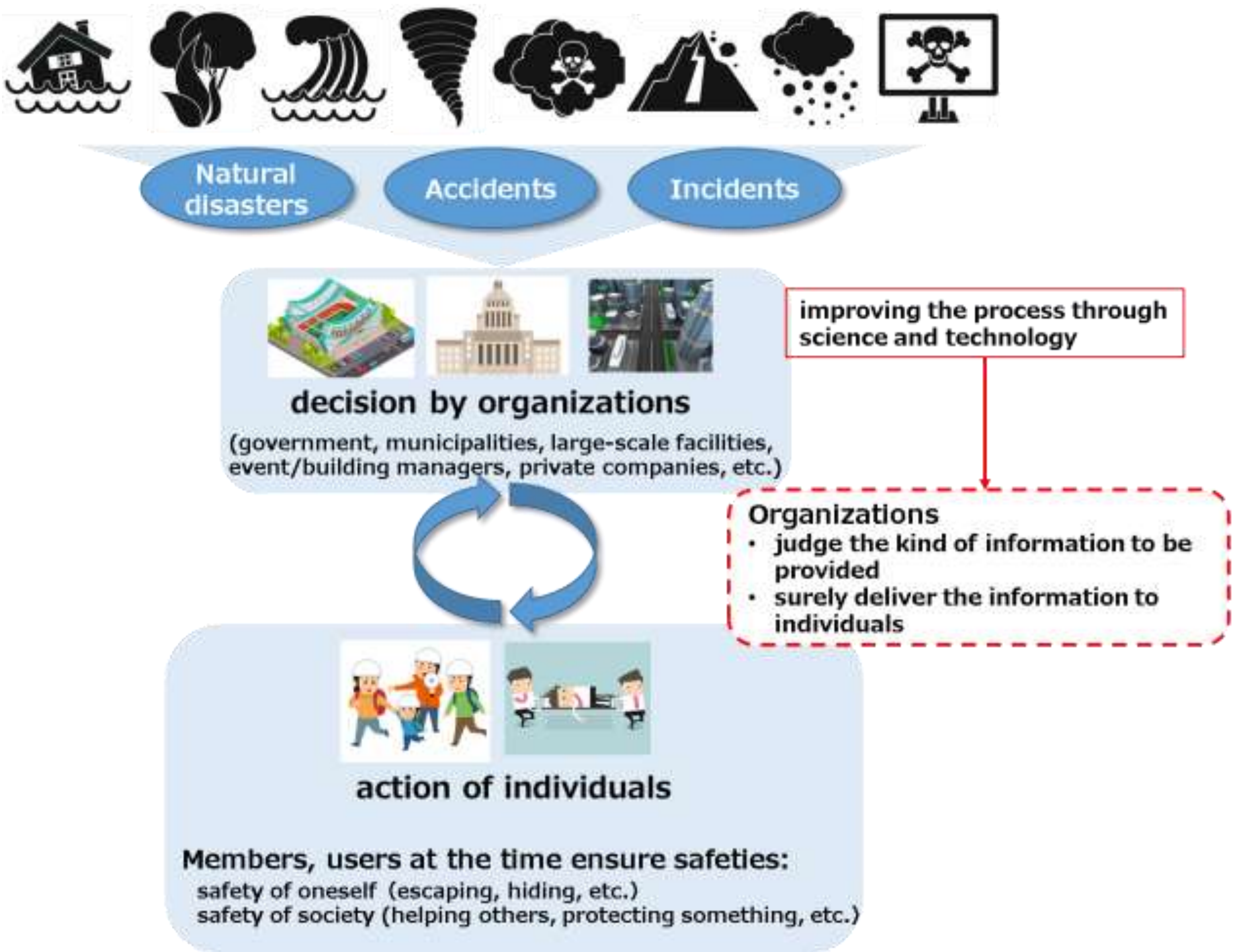

Fig.2 The aim of the crisis navigator for individuals

This navigator system would be able to provide not only the options for individuals with guide evacuation, but also each member of organizations, such as employee, with proper options for urgent responses, such as evacuation guidance. Therefore, it would give significant impacts to both individuals who want to secure safety in their daily lives and organizations which want to be recovered from damages caused by hazard. Also it is presumed that navigator would contribute to develop new markets in recipients of its research outcomes; service industries (specifically, security companies), information and communications industries, and construction industries.

To add the useful functions for daily life other than emergency, the crisis navigator would be able to appeal additional values to the companies and administrative organizations which are introducing the navigator.

(2) Policies of the R&D Supervisor for proposal selection and R&D management

① Policies for proposal selection

We aim at developing a navigator to greatly support response to hazard, mainly on initial response stage, by science and technology. Its realization needs the following technologies:

1) Observe, measure, determine and collect various information in a timely manner (prediction, prevention)
2) Integrate different kinds of information (information processing)
3) Derive options from the integrated information (information analysis)
4) Assured delivery of the options to individuals in a timely manner (information infrastructure, communications device)
5) Integrate the above technologies (systemization)

Improving accuracy of decision by organizations requires collecting quickly as much information as possible, visualizing situations and making a situation understandable (analyzing) and usable. It takes upgrading and optimizing of technology 1)-3). An assured delivery of decision to individuals also needs an upgrading and optimization of technology 4) as a stable means for communications under any situation and means for communications that can be used without power supply. For developing a system as a “navigator,” 5) is essential. Therefore, 5) is the must for the research proposals. It is not necessary to renew all of the 1)-4) technologies. It is welcomed to take advantage of existing research achievement.

Also, the research proposals should presume an image of specific implementation and practical use. Please describe clearly and specifically an image of implementation in the society in 2030 for research proposal in Application Form. Moreover, please describe the target hazard as well. It is not necessary to choose a single hazard. We welcome proposals of “navigator responding to crisis” that can be implemented for several or all hazards.

For example, in the case of an earthquake, an emergency center of a building follows a manual prepared in advance to decide what instructions a person (manager at the center) must give to people inside. However, the extremely small number of managers have experienced an unprecedented earthquake, and they will conceivably be at a loss in decision making. Moreover, the manager needs to surely deliver the decision (instruction to evacuate) to people inside. The manager may deliver different information to varying persons, instead of issuing the same information to all the people inside. Such a situation may call for the development of a technology that surpasses conventional means of communications, such as broadcasting inside a building or a smartphone. Therefore, it is expected to build a “navigator responding to crisis,” which integrates the above described functions. A conceivable specific example is given below for the research and development problem. However, this is a mere example. Please submit a proposal based on free ideas without being influenced by the example.

(An example of R&D under this theme)

<u>Development of a navigator responding to crisis for security guards by the gate-free and real-time entry security system and decision making system</u>

Develop a “detection system for gate-free and real-time entries and exits” that is a security system for closed space, such as a stadium with a capacity for 10,000 people, by using metrical and measuring techniques to detect all kinds of hazards (harmful chemical substances, organisms including viruses and bacteria, lethal weapons, and arms) without stresses on audience, such as stranding or going through a security gate. Use the detection system and high-level information processing techniques to improve the accuracy of judgement by a contingency center. Moreover, build a navigator system, which responds to crisis, in a large-scale facility that integrates communication techniques for transmitting to each security guard to one’s deployment position, conveying a proper way of preventing incidents and accidents depending on one’s expert skills and equipment, and guiding evacuation.

An important issue in the implementation of a navigator system in a society is how to guarantee reliability against such risks (for provider and user), including malfunction or false information. Concerning this, we encourage to consider where legal liability lies and to assess the users’ acceptance with technology development.

② Policies for R&D management

Conducting challenging R&D activities, we encourage the diversity of a research team for incorporating innovative ideas, including the interdisciplinary approach, global activities and collaboration between industry and academia. R&D Supervisor and the committee members will review your research activities and visit the research site and give you support and advices. We aim at realizing “safe and secure society in which everyone can feel protected.”

When transitioning from FS phase to full-scale research, optimization of R&D plan will be considered again through restructuring research teams and so on.

③ R&D Period and Budgets

For the research proposal submitted in FY 2017, please plan within a maximum period of three years. However, time spent in FY 2017 is calculated to be one year regardless of when the research and development starts. We evaluate your R&D activities for a full-scale research at a time specified by the R&D Supervisor in charge until the end of FY 2019. Please make a plan with a maximum total budget of 60 million JPY (including indirect expenses) in principle.

Please plan a maximum period of five years and a maximum total budget of 2 billion JPY for a full-scale research.

2. Creation of “human service” industries

(1) About the Theme

We aim at realizing “humane* services” that allow everyone feel safe, comfortable, and being secured by promoting human relations and controlling the environment around people.
(*Humane means merciful, sympathetic, and making a person noble.)

Science and technology have made our lives safe, secure, and abundant for years. The 5th Science and Technology Basic Plan (FY2016-FY2020) proposes “Society 5.0” as the image which Japan must aim for. In other words, following the hunting, agricultural, industrial, and information society, innovations based on science and technology lead changes to a new society. In our daily lives, science and technology are presumed to play increasingly larger roles in the future.

Proposed themes related to “safety and security” contained not only sudden environmental changes, such as disasters, but also anxiety and dissatisfaction associated with progress in science and technology. Several people have voiced their concerns of the possibilities which the communication taken by five senses might be diluted because of frequent use of IoT and AI technologies, and it might bring mentally and physically adverse effects to people in the future.

In considering the above, we would like to create new services using science and technology. To accomplish such goal, we have to verify what kind of services the future society will need and how science and technology will contribute to those services. For example, voice and letters are major means of our communication, whereas the way of communication in future may be able to share tactile impressions, tastes, and olfaction, which cannot be expressed in words. Many people have probably experienced having wonderful idea run through mind at bathtime or in the train. The future society may be able to create the space which people can get ideas more easily and readily. Recent progress in science and technology combined with our imagination must be able to create many wonderful services which will deliver safe, secure, and comfortable society.

(2) Policies of the R&D Supervisor for proposal selection and R&D management

① Policies for proposal selection

R&D under this theme aims at the services that recipients can accept without prejudice. The R&D is expected to contribute the society in which services based on advanced science and technology are naturally available in our life. A human interface is presumed that service recipients would accept it without any changes of their lifestyle nor acquire new skills.

We encourage proposer to clearly describe an image of implementation in the society at 2030 by using the application form.

This theme presumes roughly four categories for the call for proposals in this fiscal year. Presumed examples of research and development problems are given below. However, it is just an example, so please submit a proposal based on free ideas.

(1) Reinforcing communities: services to support adequate communications for close and comfortable connections among people, and improvement of imaginations and ideas of people through effective dialogues among them
(2) Controlling Atmosphere: services to control atmosphere for mitigating stresses that people receive unconsciously, and building an environment in which people can express their maximum abilities
(3) Monitoring physical and mental health: services to measure, determine, and control humans themselves and the environment around them to grasp their mental and physical conditions, detect latent disorders, including psychological diseases, at the early stage, and advise them to take proper actions for health maintenance such as sleep, rest, diet, and physical exercise.
(4) Keeping water and dietary safety: services to improve food safety, improve security with proper information, and services to advise individuals to take adequate drinks and food

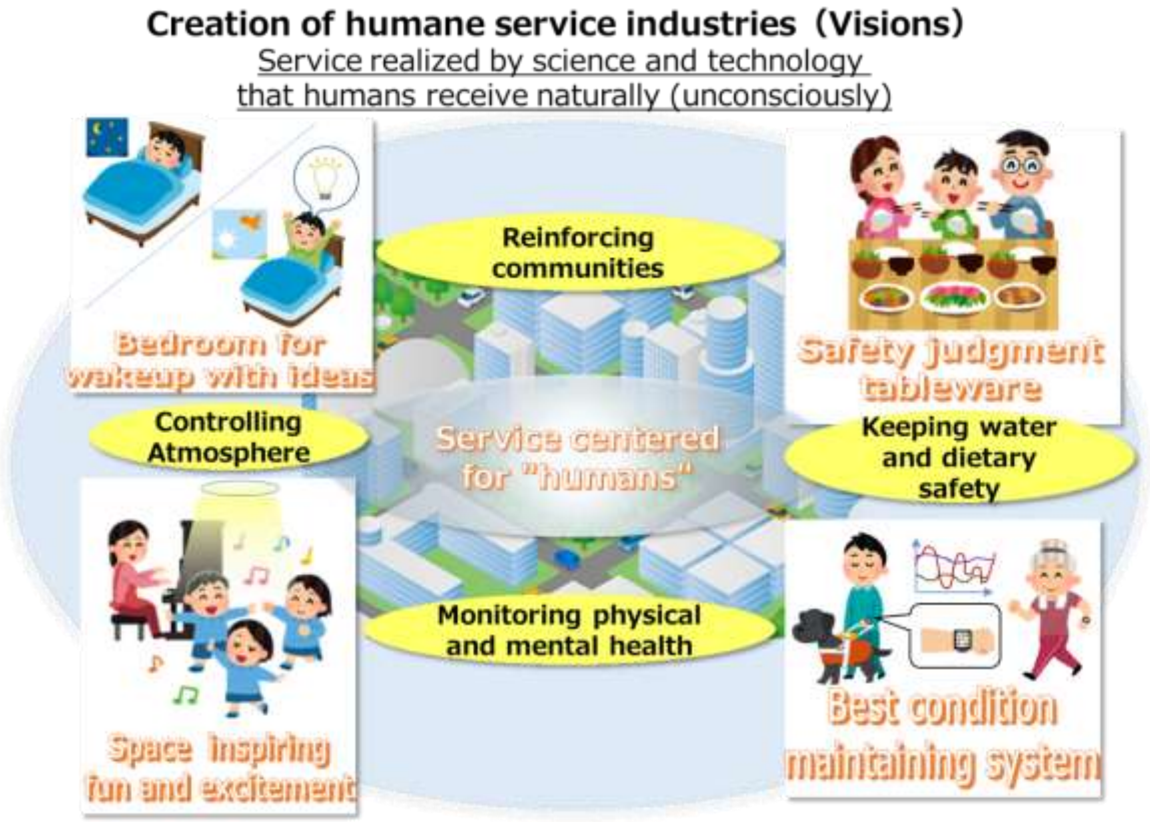

Fig.3 The aim of "humane service" industries

For planning and developing new service, we need to have comprehensive views of these ideas and expect business development such as delivering POC. Our goal is to implement services in society, therefore it is considered desirable to start with services which have evidence proving of safety, security, and comfort by basic researches and verification tests.

Along with research and development, we would like you to consider that specific activities are necessary for standardization to implement of the society.

② **Policies for R&D management**

Conducting challenging R&D activities, we encourage the diversity of a research team for incorporating innovative ideas, including the interdisciplinary approach, global activities and collaboration between industry and academia. R&D Supervisor and the committee members will review research activities and visit the research site and give you support and advices. We aim at realizing “safe and secure society in which everyone can feel secured.”

To increase chances for success in new service creation, we would like to repeat short-term challenges even at the FS stage to search for better possibility under this theme.

When transitioning from FS phase to full-scale research, optimization of R&D plan will be considered again through restructuring research teams and so on.

③ **R&D Period and Budgets**

For the research proposal submitted in FY 2017, please plan within a maximum period of two years. However, time spent in FY 2017 is calculated to be one year regardless of when the research and development starts. We evaluate your R&D activities for a full-scale research or a continuation of the FS at a time specified by the R&D Supervisor in charge until the end of FY 2018. Please make a plan with a maximum total budget of 20 million JPY (including indirect expenses) in principle.

Please plan a maximum period of five years and a maximum total budget of 2 billion JPY for a full-scale research.

5.1.4 “Realization of a low carbon society, a global issue” area

R&D Supervisor (Program Officer: PO):
Kazuhito HASHIMOTO
(President, National Institute for Materials Science)

I Goal of “Realization of a low carbon society, which is a global issue” area

Building a low carbon society is a global challenge that must be met in order to control the emission of the greenhouse gas (GHG), carbon dioxide, which is a major cause of global warming. The Conference of Parties of the United Nations Framework Convention on Climate Change (COP21) held in December 2015 adopted the Paris Agreement, which demanded that the increase in global temperature to be kept below 2°C above pre-industrial levels and that efforts be made to limit the temperature increase even further to 1.5°C above pre-industrial levels.

In response to this resolution, Japan adopted the following goal: “to decrease GHG emissions by 26% relative to that in 2013 by 2030.” In December 2015, the Global Warming Prevention Headquarters declared its intention to work toward that goal.

Furthermore, the Council for Science, Technology and Innovation agreed on “National Energy and Environment Strategy for Technological Innovation towards 2050” (NESTI 2050), which identified promising technologies for decreasing emissions and put together a promotions team for long-term research and development, while keeping an eye on 2050.

To achieve these targets, it is necessary to develop innovative technologies based on entirely new concepts and science, or game-changing technologies.

In the effort to realize game changing technologies, entirely new proposals by researchers from different fields were considered in addition to challenging proposals for which researchers in relevant fields merge, take advantage of, and develop advanced research techniques.

This area has received 344 proposals. Based on these proposals and interviews with experts in related fields, the research and development management conference evaluated potential themes for its call for proposals for fiscal year 2017 to promote creation of game changing technologies.

The theme chosen was the realization of a low carbon society through game-changing technologies. To invite specific proposals to realize a low carbon society, “bottleneck issues,” which are issues that prevent the implementation of technologies in society, were set out to identify potential solutions.

II Prioritized theme

Realization of a low carbon society through game changing technologies

(1) About the theme

This area aims to develop game-changing technologies, rather than extensions of conventional technologies, and implement these through collaborations with other projects of the JST and efforts made by other ministries. The goal is to contribute to the realization of a low carbon society with fundamentally low carbon dioxide emissions in order to meet the expected demands for services for 2050.

Fig.1 illustrates the whole scheme of prioritized theme in this area.

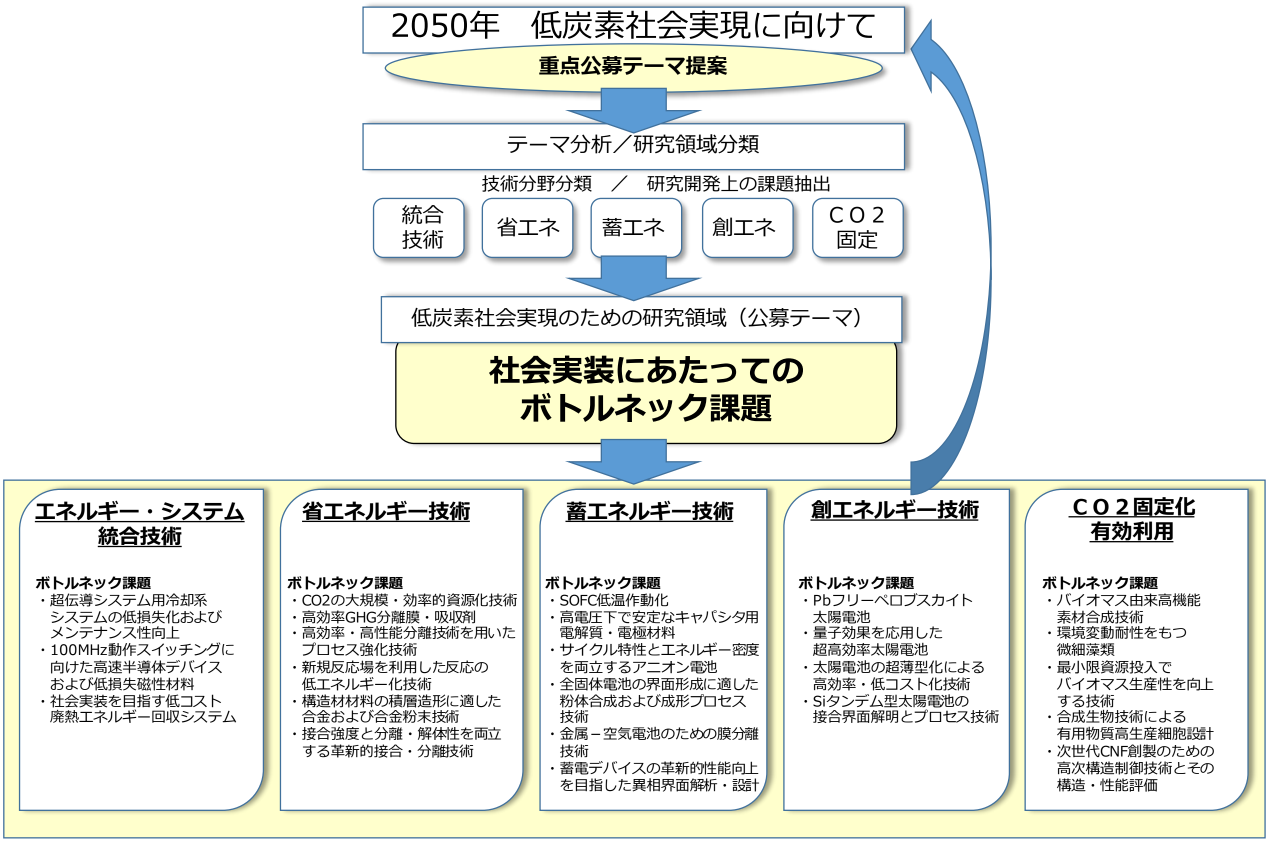

Fig.1 Overviewof the prioritized theme in “Realization of a low carbon society, a global issue” area

As described previously, the Paris Agreement adopted by COP21 in 2015 set a target of keeping the increase in global temperature to below 2°C above pre-industrial levels. This requires the “development of innovations, including technologies discrete from conventional technologies for decreasing carbon emissions, for realizing global and fundamental decreases in emissions.” Japan's role would be “to bring together the wisdom and knowledge of industry, academia, and government to promote medium- and long-term research and development in energy and the environment to realize innovations that will decrease carbon dioxide emissions and spread these achievements throughout the world.” This idea is incorporated in NESTI 2050. This research and development strategy is in accordance with the idea to create game-changing technologies. This area promotes research and development for the benefit of the wider public.

Regarding the contribution to the international community, this area may be presumed to develop approaches for collaboration with willing developing countries; for example, using advanced technologies that can play a key role in decreasing global carbon dioxide emissions through Japanese technological ability.

Japanese industries have drawn up the "An Action Plan for a Low-carbon Society of Japan Business Federation toward 2030" (prepared in April 2015, revised in April 2017). The federation is said to consider the "development of innovative technologies" as a pillar of the plan to "positively approach medium- and long-term development and practical applications of innovative technologies, with an eye toward 2030 and thereafter, while taking advantage of collaborations between industries, academia, and the government." If innovative technologies contributing to the solution of bottleneck issues inhibiting the realization of a low carbon society are created and passed on to private companies, they would be expected to not only contribute to achieving the goal of decreasing carbon dioxide emissions but also directly improving the industrial competitiveness of Japan.

(2) Policies of the R&D Supervisor for proposal selection and R&D management

● Policies for invitation and selection

To adopt issues to meet the concept of the project (verification of concept by innovative research and development), selection is based on the following criteria:

(1) Can the technology make a significant contribution to decreasing carbon dioxide emissions (not only in scientific terms)?
(2) Do private companies in charge of implementation in society need the technology?
(3) Is it innovative research that academia, such as a university, should perform?

This area will collaborate with the programs of other ministries, if necessary, to achieve the goal of implementation in society.

This area will implement the above approaches and the aim to create "game changing technologies" for fundamentally decreasing carbon dioxide emissions while meeting the demands for services presumed for 2050 and implement the technologies to help realize a low carbon society.

● Contents of research and development

The solutions to global warming may be grouped into two types, those that try to adjust the ways of nature and society in order to reduce the impact of global warming, and those that try to control GHG emissions. Science and technology are expected to contribute to mitigation measures. This area also aims to create game-changing technologies that contribute to the realization of a low carbon society by mitigation measures.

Various trials have been conducted for technologies aimed at decreasing carbon dioxide emissions. However, many of these technologies have not come to fruition. The causes of "bottleneck issues," have been summarized by those involved in this area and specifically shown to researchers. This method is based on the "Advanced Low Carbon Technology Research and Development Program" (ALCA), an approach of the JST.

In this area, POs of ALCA analyzed the contents of 169 proposals related to the area of low carbon societies from those emphasized themes applied by the public. ALCA took into consideration both new and existing bottleneck issues as a full-scale research. These bottleneck issues, classified into technological fields ①-⑤ below, are specified in NESTI 2050 to publicly invitation of research proposal. The specific descriptions are as follows:

① Energy and system integration technology

1) Low loss and improved maintenance of cooling systems for superconductivity application instruments

Superconductivity systems are approaching the stage of real-world application. However, the performance of not only the main body of the superconductivity instrument but also the whole system, including the cooling system, must be improved to beat the performance of conventional non-superconducting systems. Specifically, technological improvements are needed to realize low loss, low operating costs, and low maintenance for each instrument, including freezers of cooling systems. The development of superconductivity systems requires not only research and development in cooling systems but also meeting the requirements of the systems including their practical use. The choice of cooling methods depends on the conditions of the system. On the other hand, much is expected from innovative technologies that do not rely on application instruments but are common and basic cooling technologies to lead to a breakthrough of cooling systems. Therefore, the properties of heat transfer and flow properties of He, $H_{2,}$ and N_2; cost, size, and maintenance of low temperature instruments, such as freezers, compressors, purifiers, flow meters, level gauges; and upgrading the performance of insulated piping systems are adequately considered to perform research and development in cooling systems for superconductivity instruments that use MgB_2. REBCO, or Bi wire materials. The public is invited to submit implementation proposals.

2) Development of high-speed semiconductor device and low-loss magnetic material for realization of a 100 MHz action switching power source

At present, the total loss of electric energy supplied from power plants reaches approximately 5% of total electricity generated. Therefore, electric power converters for ①automobiles and trains need to be made smaller and lighter for reducing transmission energy; and ② conversion efficiency must be improved to control heat generation. Reactors (including inductors and converters) and capacitors made smaller and lighter by high-speed switching are effective for the former. Improved conversion efficiency for the latter is effective in two ways: it reduces power consumption owing to reduced heat generation and eliminates the need for cooling devices. The main reason for maximum operating frequency of the present switching power source remaining at MHz levels is response speed of the switching device and hysteresis loss and eddy current loss of magnetic materials. This grows clearer as switching frequency increases. One challenge that needs to be overcome is the development of low loss magnetic materials actionable at a frequency of 100 MHz and high-speed power devices. Ni-Zn ferrite currently used as a high frequency magnetic material has low saturated magnetic flux density or magnetic permeability, and is inadequate as a switching power source. In addition, power semiconductor devices such as Si-IGBT, power-MOSFET, or SiC-MOSFET have problems with switching speed and current driving force. Proposals are invited for new low loss magnetic materials that can lead to the development of promising power switching devices with wide bandgap lines and super small and high-efficiency electric power converters.

3) Development of low-cost recovery systems for waste heat energy to be implemented in society

The energy contained in medium- and low-temperature (below 300°C) waste heat comprises two thirds of the total energy consumed in Japan. The recovery of waste heat energy is key to decreasing GHG emissions that cause global warming.

Binary power generation, magnetic heat pumps, thermoelectric conversion materials, and acoustic engines have been devised as techniques for recovering medium- and low-temperature waste heat energy. However, none of them can generate enough electric power to cover the costs of system production or maintenance. The implementation of a waste heat recovery system in the future requires ① improvement of thermoelectric conversion efficiency and ② reduced system production, operating, and maintenance costs in order to recover enough energy and cover the costs of system production and maintenance.

In the case of binary power generation, for example, liquid leaking that may occur during conversion of the expanded volume caused by hydraulic liquid evaporation to mechanical energy is the main obstacle (barrier in operation and maintenance cost) to practical application. This problem can be solved by developing a mechanism for removing mechanical motion inside the tightly closed space while controlling liquid leakage when moving a piston or turbine inside the space. Proposals are invited for an innovative system that can efficiently recover waste heat energy without hydraulic fluid leakage, and devises a mechanism to recover the energy produced by binary power generation, such as ① using magnetic fluid bearings to prevent seawater leakage from the screw bearings of a ship, or ② taking energy out of motion by transmitting the reciprocating motion of a piston in a tightly closed space to an outside magnet.

For a thermoelectric material or magnetic heat pump whose material properties affect conversion efficiency, proposals are invited for the development of materials that can to recover more electric power than the costs of used elements or system production, regardless of the thermoelectric conversion index (ZT) or magneto-caloric index.

② Energy saving technology

4) Large-scale, efficient technology to recycle carbon dioxide

At present, chemicals produced from fossil resources are produced as carbon and energy sources, and then eventually released into the atmosphere as carbon dioxide. The ideal process for chemical production in a low carbon society is a carbon cycle in which chemicals are synthesized from chemical materials resulting from the carbon dioxide emitted by the energy sector and the like, and reduced with hydrogen free of carbon dioxide. Technologies to separate and recover carbon dioxide have been actively researched and developed as part of carbon capture and storage (CCS) development in each country, with some in verification testing stages. Except for polycarbonate production, however, the development of technologies to convert recovered carbon dioxide into resources has made very little progress.

This kind of large-scale resource production from carbon dioxide requires technologies for the massive production of hydrogen as a reducing agent using renewable energy without carbon dioxide emissions. However, because such technological development is a long-term solution, this issue accepts combinations with existing technologies, including the utilization of methane, which emits small amounts of carbon dioxide. Proposals are solicited for building important element technologies with priority given to large-scale and efficient conversion of carbon dioxide into resources.

Specific examples include methanol synthesis from carbon dioxide gas, Fischer–Tropsch synthetic reactions from carbon dioxide gas, carbon dioxide reforming, and improving the efficiency of the partial oxidation reaction of methane.

5) Development of efficient separation membrane and absorber for greenhouse gas

Huge amounts of GHGs particularly carbon dioxide, are emitted by the combustion of fossil fuels. To decrease GHG emissions, energy-saving technologies are being developed and the shift to renewable energies is in progress. However, the current situation indicates that the dependence on fossil fuels will last for a long time. Some simulations indicate that CCS (Carbon dioxide Capture and Storage) might account for approximately 14% of carbon dioxide reduction in the future. The current cost of CCS is over 6,000 yen/t-CO2. Substantial cost reductions are necessary for its practical application.

The separation and recovery of carbon dioxide comprise 50-60% of total CCS costs. The development of innovative separation and recovery technologies is a bottleneck to the widespread application of CCS. Various techniques are now available, such as chemical absorption, physical absorption, membrane separation, cryogenic separation, adsorption separation, etc. However, innovative technological developments are necessary for each of them.

The approaches are conceivably diverse because the operating conditions and required properties for carbon dioxide separation and recovery vary depending on the kinds of fuel used and their applications. Proposals are invited to clearly define the operating conditions and scale for each exit application and develop innovative absorption fluids, adsorption materials, and separation membranes to reduce the costs of operation and facilities, while taking into account the difference between theoretical and actual values of separation energy. In addition, proposals related to the development of new modules enabling the efficient utilization of these materials are acceptable. Proposals for the techonologies of separation and collection of the gas with the greater temperature coefficient other than carbon dioxide are also accptable.

6) Process improving technologies using efficient and high-performance separation techniques

Productivity and energy savings in chemical manufacturing processes are restricted by the energy demands and costs of separation, recovery, and recycling of non-reacted raw materials, products, and solvents. Costs prevent non-reacted raw materials and solvents from being recycled, which are a major source of carbon dioxide emissions. The development of energy-saving and cost-cutting processes requires innovative separation processes with high efficiency and performance for enhancing processes. A bottleneck in strengthening processes is the development of innovative separation and purification processes that are hybridized with various separation techniques. The technologies in question are reaction and separation techniques, including membrane reactors, reaction absorption, and reaction distillation, high-performance membrane separation, as well as membrane separation, phase separation, adsorption, extraction, crystallization, and their corresponding hybrids.

Membrane separation in particular is expected to replace distillation as an efficient and energy-saving separation technology. Various materials, such as organic polymers, inorganic materials, and compounded organic and inorganic materials, are available for membrane separation. Each one requires technological innovations in permeability, selectivity, and tolerance to enable practical applications as a separating membrane. This area invites proposals for research and development in new separation membranes, substrates to support separation membranes, and new membrane module structures and materials to save energy and reduce costs. Proposals must include the advantages (predicted) of the developed separation technology and reaction separation technology over conventional processes in terms of energy savings.

7) Technologies for lowering reaction energy using a new reaction field

C1 chemistry is a reaction system for producing chemicals via conversion of various carbon sources into carbon monoxide or hydrogen molecules, or directly from methane. However, the system has many problems. For example, methanol synthesis is an irrational process consisting of the steam reforming of methane (an endothermic reaction) at high temperatures above 750°C followed by a methanol synthesis reaction (an exothermic reaction). This process consumes a large amount of energy and emits a huge amount of carbon dioxide. Research is also underway on direct methanol synthesis by methane oxidation. However, it is not easy to stop the reaction of highly reactive methanol in methane oxidation, which has low reactivity aside from being a highly difficult reaction.

Demand exists for reducing the energy consumption of high energy processes and improving the selectivity of difficult reactions. Active research is being conducted on these kinds of chemical reactions. Rapid improvement in catalyst performance is needed.

In general, it is assumed that a catalyst is used in a thermally equivalent field. However, this area focuses on thermally non-equivalent reaction fields and the development of catalysts that are active in such fields. Proposals are invited for new reactions and reaction processes that cannot be carried out in conventional reaction fields. The means of supplying energy to new reaction fields include electromagnetic waves, supersonic waves, magnetic field, electrical fields, and their combinations. Reactions include those that are currently used for the mass production of universal chemicals despite large energy consumption as well as improved yield combined with decreased energy consumption of difficult reactions. Proposals are required to compare the energy input (predicted) for a production system using a proposed manufacturing technology.

8) Development of alloy and alloy powdering technologies suitable for lamination of structural materials

The 3D printer is a promising technology for the development of the field of heat-resistant materials. However, a supply system for high-quality and clean powders and lamination technology have not been established. For example, when a powdering technique is applied to Ni group alloys containing Al or Ti, oxides or nitrides form and cause a marked decrease in creep strength and toughness. Unlike porous ceramics such as plastics and biosystems, alloys need fundamental reexamination and tissue forming technologies combined with thermal history simulation when a 3D printer is used to avoid problems in the machinability of structural or heat-resistant materials. This is the bottleneck. Considering the above, this area invites challenging proposals for research and development in manufacturing technologies for clean powders and for the development of robust alloys that are effective in reducing contamination in powder production and lamination process, and against oxides and nitrides originating in powder surface.

9) Innovative bonding and separation technologies that possess both bonding strength and separation and decomposition functions

Industries in Japan emit the largest amount (34% in 2014) of carbon dioxide, 60% of which comes from the materials sector. Carbon dioxide emissions from material production are increasing. Recycling technologies that promote reuse and remanufacturing are effective for decreasing carbon dioxide emissions from new material production. However, bonding and separation techniques are a major bottleneck.

Innovative technologies for bonding and separation, with both bonding strength and the ability to separate and decompose, can decrease the energy consumed by decomposition and help realizing a low carbon society that recycles many products. This issue invites proposals for technologies that allow the effective utilization of existing resources, such as public infrastructure materials, their quick decomposition and reassembly, and extension of infrastructure longevity, as well as proposals that contribute to the development of bonding and separation of multiple materials by taking into consideration the recyclability of weight-reducing materials that require large amounts of energy for production.

③ Energy storage technologies

10) Low-temperature operation of solid oxide fuel cell battery (SOFC)

Although the SOFC is an efficient power source that does not require a platinum catalyst, its intrinsic technological problem is that it requires high operating temperatures of 700-900°C. Therefore, lowering operating temperatures to 500-600°C to extend longevity is needed, while retaining advantages such as high efficiency and the non-use of a platinum catalyst. To meet this objective, search and material design methods are important for rate-determining dispersion of carrier ions in the medium- and low-temperature range in electrolytes and electrode materials and for determining the optimum structure of defective structures that facilitate dispersion. Research and development in materials and structures is also important to facilitate the development of activation and stopping systems.

Proposals are solicited for a solution to the bottleneck problem; for example, science-based research and development to identify the correlation between optimum structural design and fuel cell battery performance.

11) Stable electrolytes and electrode materials for electrochemical capacitors under high voltage or high capacity electrode-electrolyte systems

Electrochemical capacitors, which excel in rapid charge and discharge, are expected to have a variety of applications including smoothing of electric power obtained from renewable energy. However, because they have lower energy density than batteries, improving energy density by developing high capacity electrochemical capacitors that can be operated at high voltage is called for. Specifically, the following proposals are expected:

- Stable electrolytes and electrode materials under high voltage (e.g., over 4 V)

- Development of electrode-electrolyte systems with higher capacity (e.g., more than double) than existing capacitors using carbon materials
- Research and development in new pre-drape technologies for Li ion capacitors to improve performance

12) Anion batteries with cycle properties and energy density combined

Insertion batteries, represented by lithium ion batteries, allow repeated charging and discharging. However, heavy and voluminous host materials limit their energy density. On the other hand, among reserve batteries using intact metal as an electrode, new batteries (anion battery) that use an anion as a mobile ion do not need a host material. Hence, they allow substantial improvements in energy density. However, their bottleneck is inadequate cycle properties. Proposals are solicited for research and development in anion batteries.

13) Technologies for synthesis and formation process of powders suitable for interface formation of all-solid-state batteries

In all-solid-state batteries, powders such as active substances for the positive electrode and electrolytes are pressed to form electrodes and electrolyte layers. These powders require specific compositions, particle sizes, crystal conditions, and optimum interfacial conditions of particle boundaries. However, these conditions are difficult to achieve and have created a bottleneck. Proposals are solicited for research and development in the synthesis of powders with optimum properties and in process technologies to form interface and compound membranes.

One example is research and development in compound membrane formation near ambient temperature for controlling the side reactions of active substance-electrolytes near the compound membrane interface. Proposals must also elucidate, based on science, the correlation between the ion conductivity of the compound membrane and its formation process.

14) Membrane separation technology for metal-air batteries

Metal-air batteries, which are expected to have the largest capacity among next-generation batteries, are operated using atmospheric oxygen as a positive electrode substance. However, steam H_2O and carbon dioxide cause metal-air batteries to degenerate, thus creating a bottleneck. Research and development in membrane separation technologies is important.

The placement of a metal-air battery in an automobile and utilization of stationary batteries are presumed to invite proposals on technologies for producing compact and light membrane separation apparatuses that can efficiently remove the above-mentioned gases.

15) Technology development for analysis and design of interface between different phases toward innovative and improved performance of electricity storage device

In the development of all-solid-state batteries, it is important to visualize and reflect on battery design information for lithium ion distribution, conductivity, and electric potential distribution in the case of lamination. Synchrotron radiation has clarified part of lithium ion distribution and conductivity in charging and discharging. However, laboratory analysis methods for lithium, which is the third lightest element, are limited. Furthermore, measurement in the direction of membrane depth is difficult, thus reducing the speed of battery development.

In the case of fuel cell, the bottleneck in its implementation is maintaining high durability while keeping the resistance to reaction and substance transfer low in the three phase boundaries essential for battery operation, including fuel-electrode catalysts or electrode-ion exchange membranes.

For example, approaches to solve these problems for all-solid-state batteries require the development of techniques for *in situ* measurement of the depth direction with a universal laboratory apparatus instead of the large ones used for synchrotron radiation. Fuel cell require technology development specifically regarding the interface between different phases, including experimental and calculation analysis and interface design of 2D or simulated 3D interfaces to control and elucidate the functions of interphases between different phases, which interact in a complex manner. The solution to these issues will have a major impact on the application to all energy conversion devices, improve performance, and accelerate implementation.

Proposals should include not only an analytical technique but also a scenario on what was revealed and how battery properties can be improved.

④ Energy creation technologies

16) Pb-free and high durable perovskite solar cell (*be sure to read “3. others”)

Solar cell containing Pb have special requirements for production and disposal, thus increasing their cost. Eliminating Pb to reduce its environmental impact is essential for the increased use of solar batteries in homes. Pb-free perovskite solar batteries have been studied but have not acquired sufficient properties.

High durable solar cells, which can be used for a long time, are in demand because solar batteries with zero durability need to be replaced within a short time. Solar batteries in practical applications are guaranteed for 20-25 years. The durability of perovskite solar batteries has been improved through process optimization but not to an adequate level.

For the reasons above, challenging proposals are solicited for the realization of Pb-free perovskite solar cell with high surability.

17) Quantum effect solar cells (control of size and sequence of quantum dots and so on)(*be sure to read “3. Others”)

Si solar cells have reached a conversion efficiency of approximately 25%. The theoretical maximum conversion efficiency is said to be approximately 29% for single bonding solar cells.Because an ordinary solar cell cannot absorb lower energy than the bandgap and loses excess energy of higher energy levels. In contrast, a quantum dot solar cell can form an intermediate band in the bandgap to convert the major portion of light energy into electricity. A light collection-type quantum dot solar cell is said to have an efficiency of over 75%. On the other hand, the actual conversion efficiency remains low, requiring the optimization of quantum dot materials and their formation methods, in addition to basic studies.

Proposals are solicited for using new concepts of quantum dot effects to realize solar cells with conversion efficiency that is twice as good or better than conventional Si solar cells. Proposals should include various solar cells using quantum dots, nanowires (wall), and near-field light (dressed photon), and photon up-conversion. No restrictions are imposed on materials or mechanisms. Proposals are expected to cover the superiority over conventional solar cells and specific manufacturing methods.

18) Manufacturing technology for super thin film crystal Si solar cells (light confinement technology, passivation technology, and production of silicon wafers thinner than 40 µm)(*be sure to read "3. Others")

Silicon wafers as thin as 180 µm have been produced. If these could be made thinner than 40 µm, the cost of polycrystalline Si materials could be reduced substantially. Furthermore, thin solar cells could be placed at sites where conventional Si crystal solar cells cannot be placed, because thin solar cells are as flexible as existing thin membrane solar cells. This would expand the range of sites for placing Si solar cells with high conversion efficiency and durable to introduce increased numbers of Si solar cells.

Si wafers may be made thinner than 40 µm by methods including crystal growth, slicing, exfoliation, smart cut, etc. Solar batteries using Si wafers made as thin as possible to minimize the amount of Si waste at production need to possess operational quality.

For the reasons described above, proposals are solicited for technologies to produce highly efficient Si wafers thinner than 40 µm, while retaining the current features solar cells for the purposes of cutting costs and expanding the range of sites for their placement.

19) Elucidation of bonding interface in Si tandem solar cells and process technology (*be sure to read "3. others")

Tandem solar cells, with absorption wavelength regions expanded by laminating semiconductors with different bandgaps, are effective for realizing solar cells with improved conversion efficiency. A Si solar battery (bandgap of 1.1 eV) with high conversion efficiency and excellent durability is optimal as a bottom layer solar cell. Solar cells of semiconductor layer with bandgap 1.5-1.7 eV are studied for top layer solar cells. Specifically, perovskite solar cells (bandgap of 1.5 eV) are used for the top layer. However, adequate improvements in efficiency have not been achieved.

The optimum bonding interface, output current, and voltage properties for combinations of different solar batteries need to be determined in order to develop tandem solar cells.

To find a solution, correlations between manufacturing process allowing optimum interface formation, structure of formed membrane, and optical/electrical performance need to be elucidated to design an optimal bonding interface for a tandem solar cell. Proposals are solicited for research and development in tandem solar cells using a Si as the bottom layer.

⑤ Fixation and effective utilization of carbon dioxide

20) New synthetic technologies for efficient production of high-performance and high-functional materials from biomass raw materials

The development of new technologies for the efficient production of chemicals and polymer materials used in daily life and industries from sugars and lignin is important to realize a low carbon society. The sugars and lignin are obtained through the separation of biomass (wood, grass) components using energy saving processes. Various processes have recently been proposed to treat wood or grass materials to separate three components:

cellulose, hemicellulose, and lignin. Rapid progress in characteristic separation techniques has led to relatively low-cost production of cellulose nanofibers, polysaccharides, sugars, and lignin.

A bottleneck in biorefinery systems is the development of new chemical and biological synthetic methods for efficient conversion of sugars and lignin into high-performance and high-functional materials. Challenging proposals are solicited for new synthetic technologies to produce high-performance or high-functional chemicals and polymer materials through energy-saving and efficient processes.

For example, the following proposals are expected:

Sugars and lignin are not converted into low cost and universal chemicals or energy materials but into

- functional chemicals or high-function polymers by technologies for chemical and biological synthesis to take advantage of the six-member ring structure of sugars and lignin, and
- chemical raw materials, such as C4 compounds or aromatic compounds, which are not readily produced from natural gas or shale gas using low cost and efficient production technologies

21) Development of fine algae robust to environmental changes toward large-scale production

The production of chemicals and fuel from fine algae, which can be produced from carbon dioxide through photosynthesis is very expected. Research has been conducted on culture conditions and genetic control techniques for efficient manufacturing of target substances. These achievements are expected to be used for practical applications, such as the production of value-added chemicals. Various attempts have been made to conduct verification tests on large-scale production. These tests have demonstrated the existence of major obstacles that are different from laboratory-scale problems and need to be overcome. The biggest problem is the markedly lower productivity of large-scale culture systems compared to systems for laboratory-scale analysis. The proper light intensities are different from kinds of fine algae. The ideal light and temperature conditions can be provided for fine alga in a laboratory. However, outdoor light intensities vary significantly depending on weather and are difficult to control artificially. Variations in light intensities make it impossible to culture fine algae at high density, leading to problems of low productivity, contamination, and high recovery costs. These problems are not confined to outdoor cultures. Large-scale cultures in closed indoor systems also face problems entirely different from those of analytical systems in laboratories, such as different environments for cells in surface layers and deep layers in a culture tank, mixing problems, illuminating deep layers, etc.

Proposals are solicited for the development of fine algae robust to environmental changes in order to overcome the bottleneck of large-scale production. The development of fine algae that can maintain productivity regardless of light intensity or depth in a culture tank, or those that can grow to high densities even under weak indoor illumination would have a significant impact on society. Furthermore, effective crushing techniques linked to the extraction of compounds from recovered fine algae would further improve the chances for practical applications.

22) Technologies for improving biomass productivity with minimum resource input

Methods for increasing biomass production, which greatly contribute to decreasing carbon dioxide, include the expansion of growth fields and improvements in productivity. An effective method is to develop plants that can adapt to limited water and nutrient supplies and maintain productivity and growth under adverse or changing environmental conditions, as well as resistance to diseases and insects. However, technologies are not yet available to obtain a fundamental solution. The input of resources, such as water and nutrients, means energy input. Decreasing inputs is important from the viewpoint of energy input per yield.

Hence, proposals are solicited for the development of epoch-making plant breeding methods for plants that grow well even with markedly small resource inputs and are robust to the environment. Various ways are conceivable, including promoting substance incorporation into plants and substance movement in plants or addition of new metabolic pathways to allow plants to utilize untapped nitrogen sources. Technology development is also expected for optimum design and breeding that allows plants to maintain their total balance at high levels through links with photosynthesis, metabolism, and hormones.

Proposals are solicited for technology development for compounds controlling environmental microflora and for understanding not only the abilities of plants but also the interactions between plants and microbes in order to isolate and identify symbiotic microbes that promote plant growth or contribute to resistance to disease and insect damage so that they can be utilized for microbial agents. Differences between microflora are important factors that contribute to plant growth due to soil quality. A future issue is to elucidate and efficiently control the actual situation. For instance, the development of plant culture technologies to maximize microbial functions as well as determining the compositions of microflora in excellent fields can facilitate the utilization of microorganisms as a practical technology for increasing plant biomass. Research on the use of metagenome information for plant modification is also welcome.

23) Synthetic biology technologies for designing cells with high productivity for useful substances

Decreasing manufacturing energy by introducing bioprocesses for substance production is expected to decrease carbon dioxide emission. Progress in universal application of bioprocesses, omics analysis, systems biology, flux analysis, genome editing, and genome synthesis technology for scaling up has enabled artificial metabolic pathways to be introduced into microbes and new substance producing ability to be provided to microbes. Such research has attempted to synthesize chemicals from various sugar materials and low molecule gases such as carbon dioxide or methane. However, the introduction and modification of a metabolic pathway frequently results in inadequate productivity owing to reasons such as dissipation into transiency and redundancy, no expected effect, and slow growth resulting from broken balance of metabolism, energy, and oxidation and reduction. In addition, it is necessary to decrease energy input in substance production. This requires the development of new methods based on the functions of autotrophic microbes. Furthermore, there is a problem that targeted products are toxic, which prevents their production. Proposals are solicited for the development of synthetic biology for designing a whole cell that is optimal for substance production, such as building an optimal combination of an artificial pathway with a system for producing energy and reducing power supply. For instance, the following proposals are expected:

- ･Development of an efficient ATP-reducing power regeneration system that is common to several kinds of microbes and can be introduced into them
- ･Technologies for utilizing the functions of autotrophic microbes, including electron supply, chemical energy supply, and carbon fixation
- ･Establishing techniques for efficient creation of artificial enzymes that are necessary for artificial metabolic pathways
- ･Establishing reasonable designing techniques for a genetic circuit that can produce toxic substances while improving yield and energy utilization efficiency

･Development of synthetic biological designing tools using the abovementioned techniques.

･Development of platform host cells that are suitable for synthetic biological development

24) Technologies for controlling multiple dimension structures for creating next generation cellulose nanofiber materials

Technology development has allowed for progress in efficient separation and purification of cellulose nanofibers (CNFs) with a diameter of approximately 20 µm from wood materials to initiate industrial trials for CNF production in Japan. The tensile strength (3 GPa) and elastic modulus (140 GPa) of CNFs are close to those of aramid fibers. CNFs have considerable potential as a high function material. Furthermore, as the surface of CNFs can be chemically modified for introducing various functional groups or for high density adhesion of metal ions or metal particles, CNFs have considerable potential as a high function material. However, the manufacture of a high performance and high function material from only hydrophilic CNFs or from their combination with a resin requires technology development of precise structural control of laminated multidimensional structures on CNF substrates in each layer. Challenging proposals are invited for technology development to use CNFs for designing and creating next generation materials.

Public invitation of research upon setting out the above-mentioned bottlenecks would build a research system that sets appropriate issues and shares objectives that contribute to the realization of a low carbon society in the entire area while researchers use various viewpoints and methods.

The costs and merits of a relevant technology must be adequately considered for solving these bottlenecks and implementing achievements in society. Reasonable prediction and evaluation of the carbon dioxide emmission decreasing effects of a technology is required for the technology to be introduced and applied widely in society, according to the issues considered by ALCA in the past and those considered by the future society creation project (low carbon society) in this fiscal year. The following proposals are invited in addition to the abovementioned bottlenecks:

⑥ Cost engineering for low carbon technologies

From the viewpoint of the focused input and impacts of limited resources on society, it is important to introduce the functions of the research and development issue, i.e., “cost engineering for low carbon technologies," into project promotion in this area. Cost engineering of low carbon technologies refers to the reasonable technological prediction and evaluation of the effects of decreasing CO_2 emission. The systems for research and development in this area will be introduced into future society. It is an indispensable approach for the widespread use/application of achievements in a society in 2040s and for reaching the target of "80% decrease in greenhouse gas emission in 2050." Proposals are invited for issues in the execution of cost engineering in relation to the development of technologies to be promoted in this area.

Cost engineering evaluation includes the research and development fields aiming at a low carbon society, including issues adopted by ALCA. Low carbon technologies and systems are selected to estimate cost perspectives, the time required for establishing and industrializing a technology, and market size. Specifically, technology levels corresponding to the developmental stages of low carbon technologies and systems are estimated to calculate system cost. In addition, the cost of implementation in society is calculated by considering the market size of the presumed product.

Evaluation will cover the relevance of the analysis and policies about whether a promoted technological field and a research and development issue should be a priority subject of cost engineering. Furthermore, it is desirable for a method to be applicable to a wide range of technological fields.

The results of cost engineering are planned to be utilized for the recoordination of targets for related issues and stage gate evaluation for promoting this area.

⑦ New approaches for a low carbon society

In addition, proposals are solicited for issues that are independently set by researchers for the "the realization of a low carbon society." However, as this area aims to achieve a low carbon society by applying mitigation measures through technology development, proposals related to adaptation measures, including observation of climate changes and ecological influence, are excluded from subjects.

<Presumed applications of achievement>

This area promotes challenging research and development to solve the abovementioned bottlenecks. It contains technologies that require considerable time before practical application. Therefore, this area collaborates with other JST projects and the programs of other ministries at an early stage and the study will be made, in addition to the transfer of the results to the industry, on the possible transfer to the program close to practical application for those programs that requires a longer period of approach in a research and development. Specifically, this area aims at collaborating with ALCA, which is presently in progress at JST, to aim for synergy.

In addition, this area aims to collaborate with "Unexplored Challenge 2050," which was initiated in FY 2017, among lNEDO's leading program for energy and environment programs. To initiate innovative research and development toward the realization of a "low carbon society" in 2050, JST promotes basic research mainly with universities and NEDO aims to implement achievements primarily from collaborations between industries and academia. The coordination is in progress at present.

● Implementation System

FS adopts challenging research topics while firmly considering exits. Stage gate evaluation analyzes whether research is moving toward the realization of a low carbon society. Stage gate evaluation is not a method of "weeding out," but of evaluation for "Enhance awareness toward a correct direction of good research for effectively encouraging and enlightening." It should be noted that it is a method for developing a technology that could significantly contribute to decreasing carbon dioxide emission in future.

In full-scale research, this area consists of "the possibility of contributing to a low carbon society" in management and accelerates research and development toward implementation in society.

● Contents to be contained in FS

The requirements that have not been met or are not predicted to be met should be clearly described in the context of selection criteria, research and development contents, a performing team, and the contents of research and development to be carried out during the FS stage, in addition to the targets to be achieved upon the completion of FS.

For instance, proposals containing the following contents are presumed:

・A FS shall perform theoretical verification of an innovative technology and set a target for making scientific and technological risks evident toward POC.

・The optimization of an entire resource and product cycle should be proposed at a stage of ideas, concrete ideas should be prepared for a cycle that maximizes societal and industrial impacts during FS, and an optimum team of private companies and academia should be created.

・Application to products should be proposed at an idea stage, a collaboration system with industries should be developed during the FS stage, and a product with high impact should be selected as a case of achievement development.

● Policies for promoting research and development

JST has been carrying out ALCA since 2010. As ALCA is intensely conscious of the "exits" of a research program specified for the development of low carbon technologies for decreasing greenhouse gas emission, it is developing various approaches that have not been observed in conventional basic research projects. A characteristic example is a "small start and stage gate method."

This method considers several issues of a relatively small funds (small starts). Issues that pass stage gate evaluation are accorded emphasis to be expanded at research scale.

Furthermore, ALCA develops approaches to accelerate measures for research and development toward the implementation of achievements in society and passing achievements for practical application, including promotion of top down research, development aiming at clear exits, collaboration with related programs and projects of other ministries including the Ministry of Economy, Trade and Industry, and bottom up (small start & stage gate evaluation) research and development. Figure 2 illustrates the framework of ALCA projects including the abovementioned.

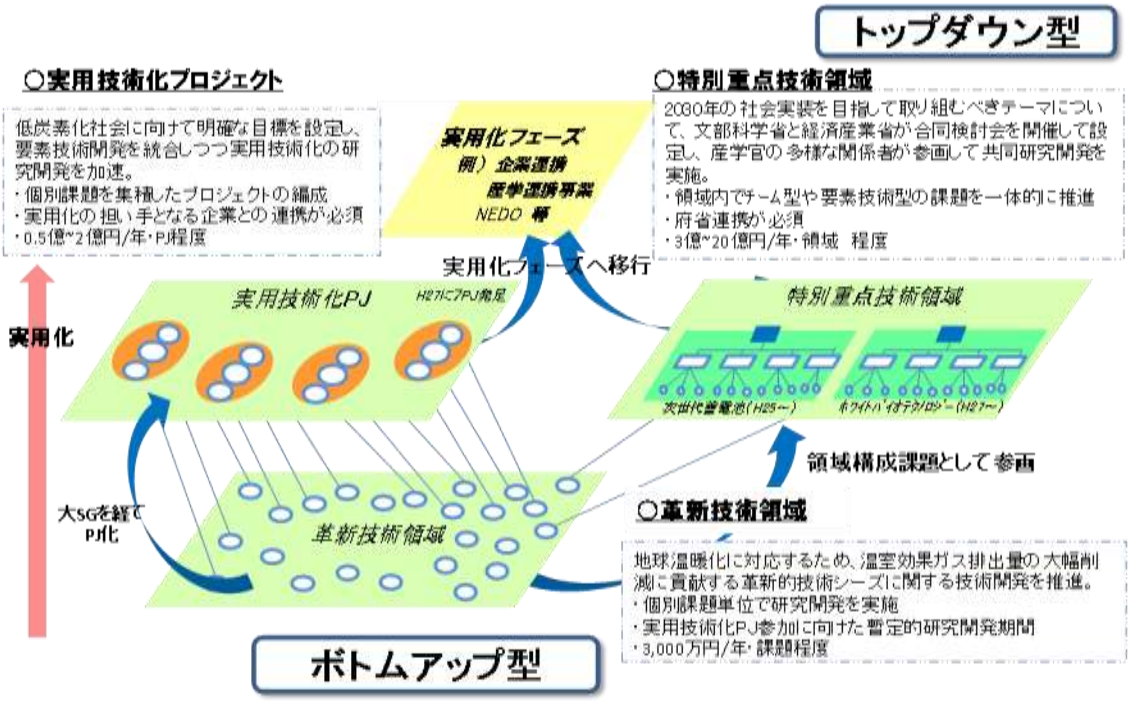

Fig.2 Sructure of ALCA

It is expected that this area will rapidly progress to application to society and industries at a stage where the solution of a bottleneck has significant impact on society and industries. Therefore, transfer to full-scale research is positively examined during FS stage. Furthermore, the rearrangement of a research team by merging several research and development issues may be presumed when a R&D Supervisor judges that it is necessary for the maximization of societal and economic impacts.

● R&D Period and Budgets

The standard research period for research and development issues initiated in FY 2017 is four and a half years to the end of FY 2021. The maximum research fund is 140 million yen (direct expenses) for the entire research period. The proposal should be based on the following maxima of the research fund:

R&D budget plan (maximum direct expenses)					
FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	
10 million	20 million	30 million	40 million	40 million	(JPY)

The viewpoint concerning whether a FS can be transferred to full-scale research after completion is a judgment criterion.

(3) Other matters

Please ensure that you read this description for proposing following bottleneck issues:

Bottleneck issues

④ Energy creation technologies

16) Pb free and tolerant perovskite solar cells

17) Quantum effect solar cells (size and sequence of quantum dots)

18) Manufacturing technologies for extremely thin skill crystals and Si solar cells (light confining technologies, passivation technologies, production of silicon wafers thinner than 40 μm)

19) Elucidation of the bonding interface in Si tandem solar cells and process technologies

1) Types of proposals for call

The research environment (hereafter referred to as “core facility”)[*2], which was set up by the Ministry of Education, Culture, Sports, Science and Technology (MEXT)atFukushima Renewable Energy Institute, AIST (FREA) (Koriyama City, Fukushima Prefecture), will be utilized to accelerate research for a “Fukushima Top-level United centre for Renewable Energy Research – Photo Voltaics Innovation (Future-PV Innovation)”[*1] to invite the following two types of proposals:

(a) Proposals for “platform type” research and integrated activities of operating, maintaining, and managing the core facility[*3]

(b) Proposals for “research type” research only

(a) “Platform type” research

This type is for proposals for integrated activities of operating, maintaining, and managing the core facility, based on the assumption of utilizing the facility to promote research for solving bottleneck issues. Furthermore, a researcher whose proposal to (b) is accepted may use the instruments at the core facility to work as a platform of this field. Attempts are expected for accelerating the research associated with solar cells in this project. Expenses for operation, maintenance, and management will be added to the research fund.

(b) “Research type” research

This type is for proposals for solving bottleneck issues. Visitors may use the instruments at the core facility operated by the platform type.

Selection is consistently based on evaluation items and criteria described priviously and by the evaluation of research aspects only. JST separately examines proposals to (a) for appropriateness in maintenance and management centered at safety after evaluation based on research aspects. Ultimately, only one platform type proposal will be accepted. A proposal to (a) may be accepted as research type.

*1 “FUTURE-PV Innovation” is commissioned by MEXT to JST in FY 2012-2016. JST set up a research environment associated with efficient Si solar cells at FREA (Koriyama City, Fukushima Prefecture) to carry out research and development.

*2 At this core facility, instruments are collectively set up for an integrated series of research. These include processing apparatuses (such as a CVD that uses special high pressure gas, a sputter, and an imprinter) and basic facilities such as clean rooms, drat chambers, and evaluation apparatuses (such as a sun light simulator and a scanning electron microscope). The availability of important apparatuses for relevant bottleneck issues is expected to effectively and efficiently promote research and development in relevant fields for this project. The space and instruments at the core facility are assets of AIST and MEXT. They may be rented for use on contract.

*3 The operation, maintenance, and management of the core facility includes maintenance and management of instruments, safety and compliance with related laws, duties related to contract, and other activities at the core facility. Furthermore, the operation of the core facility must follow the rules, safety reviews, and safety advice provide byAIST. At the completion of a project, the original condition of the space should be restored (details specified by JST) and the space should be returned to AIST. Instruments may be transferred to an organization that the proposer is affiliated with or disposed upon approval by MEXT. The expenses for operating, maintaining, and managing the core facility are assessed and added to the research fund.

2) Notes for the preparation of proposal documents

ⅰ Please ensure that the name of a bottleneck issue and the type of research, i.e., “platform type” or “research type”, are stated in the column labeled “Prioritized theme” in a proposal document when proposing the abovementioned bottleneck issues.

(example)

Prioritized theme	Realization of a low carbon society through game changing technologies, B16: Pb-free and high durable perovskite solar cell [Research type]

ⅱ In case of a proposal to “platform type,” please ensure that the contents of using the core facility (in relation to research), operating system (maintenance and management), and response system as an organization (remote response) are described in the column labeled “other specific matters” in the proposal document. However, no funding plan is required for maintenance and management.

3) Details of core facility functions

A briefing about the details of instruments and laboratory is planned to be conducted at the core facility. An announcement will be made at our website later.