[Tentative Translation]

Report on
The 5th Science and Technology Basic Plan

Council for Science, Technology and Innovation

Cabinet Office, Government of Japan

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[Translation in progress]

Introduction

Our country and the world are in the midst of an upheaval.

The question is whether science, technology, and innovation (STI) can contribute to sustainable and inclusive development here and abroad. The Fifth Science and Technology Basic Plan is expected to be the answer to this question and provide a compass that will guide the Japanese people, as well as people across the globe, to a more prosperous future.

In the 17th century, the fledgling years of modern science, Robert Boyle wrote future predictions about what we today now know as organ transplants, satellite positioning systems, and other forms of technology. It has taken many long years to bring those predictions about, but recent science and technology, especially the development of information and communications technology (ICT) is now changing economic and social rules in the blink of an eye, while also impacting our lifestyles and the very existence of society and humanity. Innovation is now manifesting itself in places beyond the traditional boundaries and is spreading across the world almost instantaneously.

With the advance of globalization, nations have become ever more interdependent, and the various issues of each country now escalate to the global scale in a flash. Domestically, the declining birthrate and the aging of our population are accelerating the drain on our rural areas. These issues must be addressed, and a social framework must be built that will ensure that each citizen can flourish and achieve a prosperous life.

As information networks advance and t human resources become more fluid on a global scale, flexibility and receptivity will be essential to enjoying the diverse values of society.

In the Fifth Science and Technology Basic Plan, science and technology innovation policy is strongly promoted as a major policy for the economy, society, and the public.

A culture of “boldly challenging the future” will be cultivated to create future industries and transform society. A “super smart society” designed to make people prosperous will be posed to shape our future, and efforts will be enhanced to build a framework in order to create new value, services, and businesses, one after another. STI will also be strategically utilized in international collaboration to help address both domestic and international issues. In order to respond flexibly to any change, the foundations of STI will be strengthened to achieve knowledge implementation with a sense of speed into society. An open, global innovation system will be built to better develop and secure brilliant professionals.

The Science and Technology Basic Plan must resonate with and be executed by those in the fields of research, development, and innovative initiatives. In order to maximize the potential accumulated from investments to date, universities must be reformed with the recognition that they contribute to society through their education and research, and partnerships between industry, academia, and government must be expanded. Additionally, working with the public will be promoted with the aim of transforming society through STI.

Executing the Fifth Science and Technology Basic Plan will require a wide spectrum of parties—including the government, academia, industry, and citizens—to work together. By executing the Basic Plan, we will grow the national economy and create jobs, secure safety and security for our country and citizens, make lives more prosperous, and contribute to global development.

Chapter 1 Basic Concepts

(1) Recognition of current situation

The economy and society encompassing Japan is in a period of great change.

Entering the 21st century, it is clear that science and technology have made great progress. In addition, the rapid progress of information and communications technology (ICT) in recent years has brought about a new reality in which information, people, organizations, logistics, finance—in reality, everything—are constantly connected on a global level and mutually influence one another. This is starting to produce hitherto non-existent synergy without being bound to the confines of existing industrial structure and technology fields, thereby creating new businesses and markets, and is also starting to change how we work and live.

Furthermore, as our economy and society matures, values are diversifying, with people's interests shifting from the tangible to the intangible. Rather than just seeking conventional technological innovations, users now demand new values and services to be created that resonate with their diverse needs.

Globalization is progressing further and further, and various social activities are expanding beyond international borders. As companies actively scramble to expand their activities worldwide in anticipation of changing global markets, they are being exposed to tough international competition. Under these circumstances, competitiveness is largely coming to be predicated by how well a company utilizes various knowledge and technology spread across the globe, and the abilities of superior personnel.

Additionally, as the intellectual frontier expands, it is becoming increasingly difficult for individuals and individual organizations to produce all the knowledge and technology necessary for success. Thus, when creating new knowledge and value, it is increasingly important to form and act in teams by bringing together people with diverse specializations. Furthermore, with the intensifying global competition surrounding innovation, open innovation initiatives that actively incorporate outside knowledge and technology will be of increasing significance to companies. In response to this, open science is also becoming the worldwide trend in scientific research. Encouraging scientiststo share and make mutual use of research findings across fields and national borders is increasing the possibilities for creating knowledge and value outside conventional frameworks.

Meanwhile, networks are rapidly expanding on a global scale and have the potential to overturn the conventional rules of society and people's values. Because of this, it has become essential to create new rules for protecting personal information and establish codes of conduct to handle the security ramifications. Turning to the Internet of Things (IoT), robots, artificial intelligence (AI), regenerative medicine, and neuroscience, it is clear that developments in these new sciences and technologies will have a great impact on not only human lifestyles but also human existence itself. This will require a rethinking of the relationship between society and science and technology.

These different changes are all interrelated and progressing at an accelerating rate. The process

of creating knowledge and value has changed dramatically, and it is ushering in a “revolutionary era” where the structure of our economy and society go through significant change on a daily basis.

It must also be noted that issues in Japan and the world are increasing in number and becoming more complex.

In Japan, the most pressing issues are energy, resources, food limitations, a declining birthrate and aging population, and the impoverished rural economies and communities. In particular, the importance of stable and inexpensive supplies of energy and resources in supporting the basis of our economy and society was once again highlighted in the Great East Japan Earthquake. Additionally, the increasing social security costs that come with the progression of an aging society and our deteriorating infrastructure are increasing social costs and becoming a major constraint to upholding and improving our economy, as well as the living standards of our citizens.

Furthermore, there is demand for appropriate responses to the risks of large-scale earthquakes, volcanic eruptions, and other natural disasters, as well as the changes in the Japanese security environment, and the need to increase the resilience of our land and social functions. It should also be noted that the reconstruction from the Great East Japan Earthquake is still a work in progress and efforts must be made to stay its course.

Looking internationally, global issues abound. The world population continues to increase, and food and water resources are becoming increasingly deficient. There are also the threats of infectious disease and terrorism, widening income disparities, and environmental issues such as climate change and reduced biodiversity. As nations become more and more interdependent, Japan must actively contribute to a global framework for handling such issues and, as a developed country, make proactive contributions to international peace and development with the people of emerging and developing countries. In doing so, it is important for Japan as an Asian country with the most advanced science and technology to make comprehensive use of our knowledge in the humanities, social sciences, and natural sciences to promote and disseminate internationally initiatives for building economic and social systems that will simultaneously help solve these problems and grow the economy.

Thus, as the economy and society go through significant changes, continued strong promotion of STI[1] is vital in paving the path to a new future and continuing to meet these challenges at home and abroad. In light of the diverse usefulness of science and technology, and the fact that research and development (R&D) findings in one area can be applied to others, it is important to build processes for dynamic innovation and utilize the findings appropriately.

(2) Achievements and challenges in 20 years of Science and Technology Basic Plans

We are now approaching 20 years since the First Science and Technology Basic Plan

1 Innovation in creating intellectual and cultural value based on new knowledge from scientific discoveries and inventions, and expanding this information to create economic, social and public value

(hereinafter “Basic Plan”) was developed in 1996 based on the Science and Technology Basic Law, enacted in 1995.

At the time the Science and Technology Basic Law was enacted, there was a demand for Japan to contribute to addressing the issues facing mankind and shift our policy from following the West’s lead in science and technology to challenging unexplored science and technology fields ourselves, and to opening our own path to the future as a world frontrunner. With that said, in Basic Plans to date, emphasis has been placed on strengthening policy in areas including securing government R&D investments, reforming the R&D system (by enhancing post-doctorate programs, developing competitive environments, etc.), strategically focusing R&D, enhancing R&D facilities and equipment, and promoting international exchange and collaboration.

In terms of government R&D investments, clear target figures have been set since the First Basic Plan. Subsequently, the Japanese R&D environment has been firmly established, with growing amounts of investment for 10 years, as well as growing numbers of researchers and articles published. Japan has become increasingly competitive internationally, even as emerging nations and other countries have gotten stronger in their science and technology endeavors, and as science and technology activity increases both in scale and complexity. We have done so through initiatives including focused investment in research areas of high importance, development of research centers with world-class competitiveness and large-scale research equipment, and the introduction and promotion of highly competitive human resource systems.

Meanwhile, with the changes in Japan’s international competition environment since the turn of the 21st century, there has been strong demand for R&D findings to give back to society, and for Japan to be more competitive and contribute further to social reform. In response to these changes, the Basic Plan has also evolved by promoting industry and academia collaboration and interaction. In the Fourth Basic Plan, the importance of innovation took the forefront, and the R&D focus was diverted from being based on the conventional science and technology fields to problem solving. With these developments, joint research between universities (including inter-university research institute corporations; hereinafter the same), R&D institutions, and companies has steadily increased, along with the numbers of patents held and income and reimbursements for patents.

In addition, in the interest of using STI to address various economic and social issues, initiatives for industry, academia, government, and relevant ministries to work together in R&D and social implementations have been advanced, such as the cross-ministerial Strategic Innovation Promotion Program (SIP). Furthermore, in 2014, the Council for Science and Technology, which oversees science and technology policy was reorganized to become the Council for Science, Technology and Innovation and started new approaches.

Thus, over the past 20 years, a concerted effort by the country as a whole in advancing science and technology policy based on the Basic Plan continues to contribute to development in Japan and across the world. Several examples of science and technology that have either brought about great lifestyle and economic change, or which could make changes in the future, have appeared. The invention of blue light-emitting diodes (LEDs) has given rise to numerous lighting

applications, and the creation of human induced pluripotent stem (iPS) cells has developed into applications in regenerative medicine. There have also been contributions to solving global problems, such as infectious diseases. Through it all, the fact that Japan has the world's second most Nobel Prize laureates in the natural sciences in the 21st century is a testament to our great presence in science and technology in the world.

Despite these achievements, there are several issues of concern. As the first point to be addressed, Japanese STI has seen its foundation rapidly weakened in recent years. Our research papers are dropping in international rank, both in quantitative and qualitative terms. There have been delays in building an international research network, and Japanese science and technology activity is regrettably starting to fall behind the world leaders. Additionally, in terms of active STI researchers, no environment is yet in place where young researchers can fully demonstrate their abilities, and many of our high-capability students are hesitant to pursue doctoral courses. As Japan’s young population is expected to shrink further in the future, solving such manpower problems is a pressing issue for STI.

It is also noteworthy that industry–academia collaboration has yet to reach full maturity. Indeed, much of the current industry–academia collaboration is on a small scale, and there is still little mobility for researchers across organizations and sectors. Venture companies and the like have yet to reach the point of structurally transforming Japanese industry. Therefore, we need to clearly recognize that the mechanism for filling the gap between company needs and the knowledge and technology produced by universities has not fully performed its function to date. This is leading to deficiencies in Japan’s ability to innovate through science and technology.

In addition, due to the Great East Japan Earthquake and the followed nuclear power incident , as well as the recent case of research fraud and other incidents, confidence in Japanese science and technology, as well as our researchers and technical experts, is falling. Thus, the importance of rethinking the relationship between science, technology, and society, as well as promoting STI together with the various stakeholders of society, is increasing.

Government R&D investment targets have not been met since the Second Basic Plan, and government R&D investment growth has stagnated the last 10 or so years compared to the world’s leading nations.

Various systematic factors are in play in the background of the issues mentioned above. Universities, the main proponent in STI activity, are lagging behind in terms of management and human resource systems, and other organizational reform. Furthermore, there are barriers between organizations, between industry and universities, between ministries, between research fields, and more. These points must be swiftly improved.

As has been described to this point, Japan’s world standing in science and technology is falling as a whole, just as other countries are further strengthening their STI policies. In addition, the shift from science and technology policy to STI policy as given in the Fourth Basic Plan may not be progressing sufficiently. These issues must be addressed with bold reforms driven by a strong sense of crisis and speed. In the interest of extracting the most out of the results of the R&D

investments of the past 20 years, it is particularly important to reform the systems for addressing the various issues faced by STI researchers, and to reorganize and enhance the function of universities and national R&D corporations.

(3) Target National Image

STI policy is a major national policy for the economy, society, and the public that will guide our country into the future. Therefore, it is essential to policy promotion that the policies clearly present what kind of country is to be achieved and share this image with its citizens.

With the economy and society changing so greatly, and with the bevy of issues emerging both nationally and globally, the following four policies have been defined for promotion in the Fifth Basic Plan as the Target National Image for sustainable development for Japan and the world into the future. In the policy implementation phase, the Japan Revitalization Strategy will be promoted in organically linked coordination with the other major policies for the economy, national security, diplomatic relations, and education, with aims to achieve this national image to its fullest extent.

• Sustainable growth and self-sustaining regional development

Economic growth and job creation are the core supporting our national development. As such, Japan will strive to increase production in order to revitalize regional communities and society as a whole and create adequate jobs domestically, as well as to achieve sustainable improvement for our economic strength.

, Ensure safety and security for our nation and its citizens and a high-quality, prosperous way of life

To protect citizen lives and property and to help them achieve prosperity is the mission of a nation. Given this, Japan will aim to ensure the safety of our nation and citizens, and to guarantee citizens a spiritually rich, high-quality way of life.

ƒ Address global challenges and contribute to global development

Japan must continue to be country that constantly contributes to the advancement of mankind. Thus, Japan will aim to proactively apply our STI ability to responding to global issues and improving the quality of life in developing nations. We will also strive to actively contribute to sustainable world growth.

„ Sustainable creation of intellectual property

Achievement of the national image described in items 1) to 3) is contingent upon Japan as a nation having a high level of STI. Thus, Japan will aim to ceaselessly create diverse, exceptional knowledge, and to promptly implement the results in society as economic, social, and public value.

(4) Basic objectives

• Four pillars of the Fifth Science and Technology Basic Plan

In promoting STI policy to achieve the Target National Image, both the ability to be visionary and strategic in predicting what will come, and acting accordingly in strategic fashion, as well as the ability to be diverse and flexible in responding appropriately to any changes, will be stressed in this revolutionary era.

Currently, Japanese STI activity is hampered by various barriers and limited to our national borders, and is thus unable to expand to its full potential. Based on this, the Basic Plan will guide Japan to becoming “the best suited nation in the world to innovation”. Japan will achieve this by having all constituents compete and collaborate in international open innovation systems and by building a framework that can maximize the abilities of each constituent through participation by the humanities, social sciences, and natural sciences in all sectors in order to create a Japan-sourced innovation.

Based on this approach, the following four initiatives will be positioned as policy pillars of the Fifth Basic Plan and strongly promoted.

i) Acting to create new value for the development of future industry and r social transformation

In this revolutionary era, in order for Japan to remain competitive and strengthen in the future, it is critical that we ascertain domestic and international trends despite uncertain prospects and act strategically with vision to create future industries and enact social reform.

Therefore, Japan will aim to bring about great changes to itself in order to lead in the revolutionary era by advancing initiatives to create non-continuous innovation. Furthermore, we will enhance our efforts in building a framework aimed at creating prosperity for citizens. This will involve sharing the “super smart society” and incorporating ICT advances and networking, which are the major trends of the times, as the shape for our future society, and then creating new values and services one after another in this society.

ii) Addressing economic and social challenges

With the economic and social structure changing daily, appropriate preemptive action addressing the various issues that have emerged is imperative to sustainable development domestically and abroad. To achieve this, Japan will take the various issues emerging domestically and on the global scale, select the key national policy issues, and act comprehensively and uniformly to address these policy issues on the basis of the Target National Image.

iii) Reinforcing the “fundamentals” for STI (science, technology, and innovation)

In order to respond appropriately to the various possible future changes through STI, it is essential to strengthen the foundations of STI, namely, 1) the abilities of the researchers at the core of STI, 2) the academic and basic research needed for creating diverse and exceptional knowledge at the source of innovation, and 3) funding to support all STI activity. To do so, drastic initiatives for strengthening these foundations will be advanced. These will focus on reform and functional enhancement for universities, along with training and career advancement for younger researchers, who will be the ones to lead us in an era of uncertain prospects.

iv) Building a systemic virtuous cycle of human resource, knowledge, and funding for innovation

Japan’s future competitiveness is contingent upon the utilization of its human resources, knowledge, funding domestically and abroad, the creation of new value, and the prompt implementation of these new values in society as part of the progressing global initiatives for open innovation. To bring this about, a system will be built to circulate personnel, knowledge, and funds beyond all barriers, and for Japan to create innovations one after another as a world leader. This will be achieved through building real collaboration between companies, universities, and public research institutions, and by both creating and strengthening venture businesses.

In proceeding with these four initiatives, it will be essential to do so together with science and technology diplomacy, and to work to strategically expand them internationally.

STI activity has recently been expanded past national borders. In this environment, questions related to how well an international research network can be established and whether a framework that will promptly and effectively utilize intellectual resources across the globe can be built will have a great impact on Japan’s international competitiveness. Amidst the great ongoing changes in the international environment, Japan needs to raise its international profile by utilizing its ability in STI and by demonstrating leadership in the pursuit of common interests shared by Japan and the world.

Given all this, it is important in the promotion of STI policy for Japan to always take the global perspective into consideration and act strategically in its international collaboration. In this way, Japan will work to bolster global brain circulation and position a framework capable of disseminating Japan's science and technology to the world, within its science and technology diplomatic strategy, as part of the visible face of the nation.

, Important issues in the promotion of the Science and Technology Basic Plan

Upon effectively and efficiently advancing the above four initiatives, it is essential to deepen the relationships between STI and the various stakeholders of society, and to strengthen the ability of these stakeholders to promote this STI.

i) Deepening the relationship between STI and society

The perspectives of users with diverse values have become essential to the creation of innovation. Additionally, the basic premise for STI to meet social expectations is that it must win the understanding, trust, and support of society. Thus, we will engage the various stakeholders of society in dialogue and collaborate with them in promotion of STI activity.

ii) Strengthening stakeholder ability to advance science, technology, and innovation

In order to advance STI effectively, it is essential for it to resonate with universities, public research institutions, companies, and the other various main proponents involved in STI activity. The keys are to flesh out initiatives aimed at strengthening the functions of each player and to

expand industry–academia–government partnerships.

In addition, with accelerating economic and social change, along with developing a 5-year Basic Plan as the basic objectives for STI policy, every year a Comprehensive Strategy on Science, Technology, and Innovation (hereinafter “Comprehensive Strategy”) will be developed to facilitate flexible policy management.

Furthermore, we will constantly be working to improve the quality of our policies by determining the status of key indicators and achievement levels for target values. The key indicators for determining the progress and outcomes of the Fifth Basic Plan are to be determined separately, and target values will be defined in this Basic Plan for items for which the situation to be achieved must be, and can be, clarified quantitatively. Note that the target values described here are for determining progress toward achieving STI targets by the nation as a whole and are not intended for unaltered use in evaluating individual institutions or researchers. The government must take care not to let the pursuit of the target values in and of itself become the goal, or to invite unwanted results or divergence from the original aims. Moreover, universities and national R&D corporations are required to proceed with initiatives to achieve visions that leverage their individual strengths and characteristics based on the policy objectives and content described in this Basic Plan. It is imperative that the collective actions of these institutions achieve the target values by the nation as a whole given in this Basic Plan, and that an environment be built in which STI can proceed effectively.

Chapter 2 Acting to create new value for the development of future industry and social transformation

We have arrived at a revolutionary age where the process of creating knowledge and value has changed considerably, and where the economic and social status quo, as well as industrial structures, are rapidly changing. In such an age, so-called game-changing shifts are expected to occur frequently, as new knowledge and ideas conceived in quick succession significantly impact the competitiveness of organizations and countries.

The driving force of this trend is the rapid development of network connectivity and cyberspace use that has accompanied the evolution of information and communications technology (ICT). This development also indicates the overall direction where Japan, as well as the global economy and society, is heading. We are now at a stage where innovation is being generated in a variety of ways. Through the medium of the Internet, we are seeing the dramatic spread of the Internet of Things (IoT), in which objects or “things” are connected and have access to a variety of information, and the Internet of Everything (IoE), in which everything is connected to each other. New knowledge is created from the huge amounts of data that are collected. Furthermore, from the linking and merging of different matters that has never been previously imagined, new products and services are conceived to match consumer needs, thereby expanding markets instantly.

In order to create values and services that cannot be projected from the past and bring about changes to the economy and society, a new approach is necessary—one which strikes out in a new direction—in order to stimulate further challenges in addition to the initiatives that have been pursued through the past Basic Plans.

In this revolutionary age, where predicting the future outlook is difficult, we can only get ahead of the times through creating new game-changing knowledge and ideas. Toward this goal, we will foster initiatives that boldly attempt new ventures and actively generate discontinuous innovation.

Furthermore, in light of the rapid development trends of network connectivity and cyberspace use, we are proposing an ideal form for our future society, a “super smart society” where new values and services are continuously created in order to bring wealth to the people who make up society through initiatives that focus on actively using and applying cyberspace. Over the course of this proposal, we will foster initiatives that are aimed at realizing the world’s first super smart society.

(1) Fostering R&D and human resources that boldly challenges the future

To foster and sustainably develop Japan's international competitiveness in a world where new knowledge and technology are produced on a daily basis, and then rolled out as economic or social activities on a global scale, and in which the cores of competitiveness are undergoing changes, it is essential for Japan to actively produce new value and be a leader in the transformations.

In particular, the process of setting the bar high, and boldly attempting to consistently create unrivaled innovation without fear of failure, is important. New knowledge and technologies are

created by breaking out of the current customs and paradigms, continually challenging the frontiers of our present knowledge and technology, which are the roots of social transformation, and by conducting trial social implementation. Thereafter, creating groundbreaking value from such new knowledge and technologies is essential. Such value may have a major impact on competitive strength by completely changing the current rules of the competition.

To this purpose, in addition to conventional research and development (R&D), we will accelerate the creation of discontinuous innovation by adopting mechanisms for stimulating efforts on R&D that places emphasis on novel, unconventional ideas with economic and social impact. However, these policies will not be possible without the cultivation of a variety of different ideas. Hence, we will also provide opportunities for experimenting with ideas in the form of presenting R&D projects to professionals possessing highly creative ideas and the ability to act toward the implementation of those ideas. In addition, we will work on fostering and securing human resources who can effectively operate and manage projects while considering these features.

Based on all of the above, Japan will widely disseminate a suitable method for promoting "challenging" R&D in the R&D projects conducted by the government ministries. Concretely, this will involve introducing R&D management through project managers, granting opportunities to researchers possessing new ideas by enhancing their authority, implementing an evaluation that encourages research that may not necessarily have a high probability of yield (high-risk research) but that can be expected to have a significant impact if successful, implementing a stage-gate system for developing groundbreaking but highly risky research while confirming results at each stage of progress, adopting an awards system that provides incentives to research based on novel ideas, as well as efforts. Through such dissemination techniques, we will facilitate R&D that would not have been implemented within most conventional R&D projects, and encourage researchers that are up to the challenge to play an active role.

In doing so, the following should be noted: "In high-risk R&D, failure is an indispensable part of the process; there is also value in pursuing the challenge itself." Under this concept, it is clearly also important to create a framework that will make full use of such failure going forward to the next stage, or to solving other issues.

Moreover, we plan on devising ways to further develop and expand. With the "challenging" nature of the ImPACT (IMpulsing PAradigm Change through Disruptive Technologies Program) R&D project as a model case, we plan on extending similar schemes to the R&D projects under the auspices of relevant government ministries.

Note that to be able to produce game changers from the knowledge arising from "challenging" R&D, knowledge must be speedily converted into value. The role of venture businesses, in particular, is extremely important for this conversion, and developing an environment where such businesses can be created continually and flourish is vital.

(2) Realizing a world-leading "super smart society" (Society 5.0)

In a world where ICT is evolving, and where the use and application of networks and IoT is

advancing, ICT is being leveraged to its fullest in the manufacturing sector, such as in Germany's "Industry 4.0", the United States' "Advanced Manufacturing Partnership", and China's "Made in China 2025". Such efforts to lead change in the so-called fourth industrial revolution are now being laid out under government–private partnerships.

From here on, ICT is expected to further evolve so that "things", which have so far functioned separately, will be connected into "systems" using cyberspace. Furthermore, separate systems in various fields will be able to coordinate and collaborate, widening the range of autonomy and automation, and creating new value throughout society. This is expected to usher in transformational change in a broad range of industrial structures such as manufacturing, logistics, sales, transportation, health and medical care, finance, and public services, thereby changing how people work and live, and providing the impetus to realize an abundant and high quality of life for citizens.

For Japan in particular, where the impact of the falling birth rate and aging population are becoming more evident, these efforts to create intelligent "systems", and their coordination and collaboration that encompass various fields aside from the manufacturing industry, are extremely important for shaping economic growth and a healthy, long-lived society, which will lead to further social transformation toward realizing an abundant society in which each individual can live a vigorous life. Such endeavors will also spur the spreading of the fruits of science and technology, such as ICT, into fields and domains that have not been adequately reached until now, and is expected to enhance business strength and improve the quality of service.

Through an initiative merging the physical space (real world) and cyberspace by leveraging ICT to its fullest, we are proposing an ideal form of our future society: a "super smart society" that will bring wealth to the people. The series of initiatives geared toward realizing this ideal society are now being further deepened and intensively promoted as "Society 5.0".[2]

- Super smart society

  A super smart society is characterized as follows:

  a society where the various needs of society are finely differentiated and met by providing the necessary products and services in the required amounts to the people who need them when they need them, and in which all the people can receive high-quality services and live a comfortable, vigorous life that makes allowances for their various differences such as age, sex, region, or language.

Such a society is expected to, for example, develop and realize an environment in which humans and robots and/or artificial intelligence (AI) coexist and work to improve quality of life by offering finely differentiated customized services that meet diverse user needs. The society must also be capable of anticipating potential needs and providing services to support human activities, resolving gaps in service due to differences in region, age, etc., and enabling anyone to be a service

2 So called to indicate the new society created by transformations led by scientific and technological innovation, after hunter–gatherer society, agricultural society, industrial society, and information society.

provider.

In the future, with the progress in efforts toward a super smart society, one can anticipate not only the integration of several systems such as energy, transportation, manufacturing, and service but also the integration of organizational management functions such as personnel, accounting, and legal departments, as well as the work value implemented by people such as manpower and idea creation, which will further lead to the creation of value.

On the other hand, because of the high degree of merging between cyberspace and the real world in a super smart society, the damage that cyberattacks can inflict on the real world will also become increasingly severe and may seriously affect people's lives, including their economic and social activities. Thus, achieving a higher level of security quality[3] is required. Such efforts will serve as a source of industrial value and international competitiveness.

, Efforts required to realize a super smart society

In order to realize a super smart society, it is necessary to connect various "things" via a network, create highly advanced systems out of these things, and integrate several diverse systems so that they can coordinate and collaborate with each other. This integration allows for a wide variety of data[4] to be collected, analyzed, and applied across all the coordinating and collaborating systems in order to continuously produce new values and services.

However, it is not realistic to believe that a framework capable of enabling the coordination and collaboration of all kinds of systems could be constructed right away. Working toward this goal, 11 systems[5] were identified and given priority for development in the 2015 Comprehensive Strategy, based on the economic and social issues that require the strongest national efforts. By increasing the sophistication of these individual systems, we will incrementally work toward their coordination and collaboration.

First, through collaborations between industry, academia, and government, as well as the relevant ministries and agencies, initiatives for increasing the sophistication of these 11 systems will be worked on steadily, based on the tasks that are set as performance goals for each individual system. Successful cases and problematic issues will be shared across all the initiatives to allow for cross-application over the systems.

Alongside the individual initiatives for the 11 systems, a common platform will be built in stages that will allow for coordination and collaboration between multiple systems and that can be used in various services, including new services that have not yet been anticipated. In particular, because of their ability to accelerate coordination of multiple systems and improve industrial competitiveness, "intelligent transportation systems", "optimizing the energy value chain", and

3 Safety and security that are expected by individuals and businesses as elements of quality from the concerned service.

4 Web data, human activity data, 3D geographical data, transportation data, environmental observation data, production and distribution data of manufacturing and agricultural produce, as well as others.

5 Optimizing the energy value chain, building a global environment information platform, maintenance and upgrade of an efficient and effective infrastructure, attaining a resilient society against natural disasters, intelligent transportation systems, new manufacturing systems, integrated material development systems, and promoting integrated community care systems, hospitality systems, smart food chain systems, and smart production systems.

“new manufacturing systems” will be developed as core systems. Coordination and collaboration with the other systems such as “promoting integrated community care systems”, “smart food chain systems”, and “smart production systems” will be worked on as soon as possible in order to create new value in the economy and society.

However, based on the concept of security by design, it is important to promote these initiatives while incorporating security into the overall system from the planning and design stage.

Based on all these factors, Japan, through collaborations between industry, academia, and government, as well as the relevant ministries, will promote the initiatives necessary to build a common platform (“super smart society service platform”) that effectively utilizes the IoT toward realizing a super smart society.

Concretely, this will involve working on standardizing the interfaces, data formats, etc., in order to facilitate the use of data between multiple systems, promote the development and trial implementation of a highly sophisticated common security technology shared by all the systems, and develope a function that will appropriately perform risk management.

In addition, for information provided by Japan’s common platform system, such as the three-dimensional mapping and positioning data and meteorological data obtained from the Quasi-Zenith Satellite System, Data Integration and Analysis System (DIAS), and the Japanese Public Key Infrastructure (JPKI), we will work on providing a framework and developing related technologies that will enable the broad use of these data between systems.

Moreover, in order to respond to increasingly large-scale and complex systems, we plan on intensifying the development of fundamental technologies for information and communication, and building up social measurement functions that will show their impact on the economy and society along with the social costs.

Furthermore, we plan on promoting a science that is instrumental in responding to issues regarding the protection of personal information and the responsibility of manufacturers and service providers in terms of strengthening ethical, legal, and social initiatives aimed at integrating the humanities and science toward trial implementation in society. We will also promote deregulation and system reforms that will allow the provision and operation of new services and the creation of appropriate systems and regulations.

Alongside all these initiatives, we will also foster the R&D researchers needed to build the super smart society service platform, as well as those that will utilize this platform to create new value and service.

Note that these initiatives are also conducive to forming a healthy, long-lived society, which is a key issue in Japan. In this regard, the Council for Science, Technology and Innovation is furthering cooperation and collaboration with the Headquarters for Healthcare Policy, as well as with the ICT-related command center, the Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society, and the National Center of Incident readiness and Strategy for Cybersecurity. Together with laying the foundation for a cooperative network encompassing industry, academia, and government, as well as with the relevant ministries for building the super smart society service platform, the Council for Science,

Technology and Innovation prioritizes initiatives and sets detailed targets in its Comprehensive Strategy, which is formulated each fiscal year.

(3) Enhancing competitiveness and consolidating fundamental technologies in a “super smart society”

• Initiatives required to enhance competitiveness

For Japan to maintain and strengthen its competitiveness in a super smart society, the country will have to lead the world in implementing such initiatives in order to accumulate the necessary knowledge and know-how for advancing intellectual property and international standardization. Together with continuously enhancing functionality for the future platform to stimulate the creation of new businesses that will respond suitably to diverse needs, it is also important to provide unique and distinctive Japanese features to the platform and its individual systems in order to establish their dominance.

To this purpose, Japan, through collaboration between industry, academia, and government, as well as the relevant ministries, will implement intellectual property strategies and international standardization related to technologies and interfaces for the realization of the super smart society service platform.

Moreover, consolidating the fundamental technologies necessary to build the super smart society service platform and further consolidating Japan’s technological strengths, which form the core of new value creation in individual systems, are essential. The specific technological domains and their corresponding promotion measures are presented in the next section.

In addition, through promoting exports of system packages verified to have achieved their performance goals, we can create new global businesses made in Japan, and turn the issues troubling the nation, such as the falling birth rate and aging population, energy restrictions, and natural disaster risks, into strengths.

At the same time, we will foster human resources that can use the super smart society service platform to generate businesses that create new values and services, and build new business models, as well as foster those who possess basic knowledge such as data analysis and programming, and who can use the fundamental technologies such as big data and AI in discovering new issues and solving them.

, Strategic consolidation of fundamental technologies

i) Fundamental technologies necessary to build the super smart society service platform

The fundamental technologies necessary to build the super smart society service platform, in other words, the technologies concerned with distribution, processing, and accumulation of information in cyberspace, are the essential technologies in forming our world-leading super smart society and creating added value from big data.

Hence, Japan will speed up consolidation of the following fundamental technologies in particular.

- Cybersecurity: technology that supports safe information and communication, considering the characteristics of the IoT, such as the long life cycles from design to disposal

- IoT system architecture technology: technology that enables the modeling of hardware and software as components, and the building and operating of large-scale systems
- Big data analytics: technology deriving knowledge and value from large amounts of a wide variety of data, including unstructured data
- AI: technology that supports IoT, big data analytics, and advanced communication
- Device technology: technology that enables the high-speed, real-time processing of large amounts of data with low power consumption
- Network technology: technology that distributes growing amounts of data at high capacity and high speed
- Edge computing: technology that enables increasing speed and diversification of real-time processing at the actual system location, which is necessary for increasing the functionality of IoT

In addition, since mathematical sciences is an inter-disciplinary scientific technology that supports all these fundamental technologies, we will promote it together with strengthening collaboration in R&D of each technology, and when fostering professional development.

ii) Fundamental technologies that are Japan's strengths, which form the core of new value creation

By embedding components that make use Japan's technological strengths in each system's element, we can establish Japan's dominance and make it possible for the system to create new value that meets the diverse needs of the economy and society in Japan and overseas.

Hence, Japan will consolidate the following fundamental technologies in particular, which function as core technologies in the real world, for new value creation in individual systems.

- Robotics: technology expected to be used in various fields such as communication, social service/work assistance, and manufacturing
- Sensor technology: technology that collects information from humans and all kinds of "things"
- Actuator technology: technology related to activating mechanism, drive, and control devices in the real world, as well as the results of information processing and analysis obtained in cyberspace
- Biotechnology: technology transforming sensor and actuator technologies
- Human interface technology: technology using augmented reality, affective engineering, neuroscience, etc.
- Material/nanotechnology: technology that leads to differentiated systems through enhanced functionality of various components, such as innovative structural materials and new functional materials
- Light/quantum technology: technology that leads to differentiated systems through enhanced functionality of various components, such as innovative measuring techniques, information/energy transfer technology, and processing technology.

For the fundamental technologies given in i) and ii), since connecting several technologies organically is expected to stimulate mutual technological development, such as the way collaboration between AI and robotics is expected to bring about the enhancement of both AI

recognition and robot motor functions, sufficient attention must be paid to the connections between and the integration of differentiated technologies.

iii) Principles on consolidating fundamental technology

To consolidate the fundamental technologies given in i) and ii), setting high performance targets for each technology that consider the direction of change toward a super smart society from the medium- to long-term perspective of around 10 years into the future, and then working toward achieving these goals, is the key.

In working on these goals, building the framework for industry–academia–government collaboration and for facilitating R&D is vital to actualizing smooth progress toward trial social implementation of the technology. In particular, it is important to move forward with R&D not in a linear model, which begins from the basic research stage, advances to the development stage, and then proceeds on to social implementation, but instead in a spiral fashion, in which the development, social implementation, and basic research stages mutually stimulate each other. This will provide an environment in which new science can be created and innovative technology can be produced, and where developing the technology into a practical application and commercialization can be worked on simultaneously in parallel.

While going forward for R&D and human resource development with outstanding professionals, knowledge, and funding tapped from around the world, there is also a need to deeply work through the possible impact such technological developments will have on humans and society. In such technology domains as AI and security, researchers from both social and natural sciences will have to carry out integrated and actively collaborative R&D. In creating such an R&D environment, an administrative structure that can flexibly manage projects will need to be set up by gathering outstanding human resources from both inside and outside of Japan, and providing them with eminent leadership.

For the key fundamental technologies, the Council for Science, Technology and Innovation will formulate overall strategies based on the abovementioned contents, considering the perspective of all government ministries and agencies, and lead in promoting effective and efficient R&D. To accomplish this, the state of progress of R&D in each key technology domain will be evaluated to set priorities for use when going forward. At the same time, the Council will flexibly promote R&D, including appropriate revisions of technological domains and goals, in order to respond to changes in technological trends and the economy and society.

[Translation in progress]