Provisional Translation

Comprehensive Strategy on Science, Technology and Innovation 2016 (Excerpt)

Chapter 1

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Cabinet Decision

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Chapter 1: Acting to Create New Value for the Development of Future Industry and Social Transformation ★

In the era of drastic change where the process of creating knowledge and value, when economic and social forms and industrial structures are undergoing rapid transformation, we must ambitiously pursue bold new attempts to create new ideas and knowledge that will change the rules of the game, and strengthen initiatives that will actively yield major shifts in innovation. In addition, to take on economic and social challenges through the fusion of cyberspace and physical space (real space), we must lead the world in realizing a human-centered society in which people will be able to lead high-quality lives full of comfort and vitality, a society that we propose to call Society 5.0.

(1) Fostering R&D and Human Resources that Boldly Challenge the Future

[A] Basic Perceptions

The realization of innovations that will have an impact large enough to transform the nature of industry and society requires ideas and initiatives that are not simply extensions of what has come to before. While the risk of such attempts ending in failure is naturally high, to be overly cautious and preoccupied with avoiding this aspect of loss is to miss out on opportunities for gaining experience and obtaining new findings, and could even result in being left behind by change and faced with a situation that would dictate withdrawing from the field completely. In order to overcome these circumstances, it is important to anticipate the future and to engage in ambitious research and development (R&D) that attempts to clear these high hurdles without fear of failure.

Frequently, the implementation of such challenging R&D will not proceed as expected, and is likely to encounter unexpected events. When confronted by such situations, it is clear that responding (as we see on some occasions) by adhering to original concepts, stubbornly striving to carry out initial plans, evaluating them exclusively on the basis of achievement, and seeking to correct one's course so as to eliminate the difference, will not be very meaningful. Therefore, ambitious initiatives are also necessary on the part of the institutions that R&D.

[B] Priority Challenges

The Impulsing PAradigm Change through Disruptive Technologies (ImPACT) Program being conducted under the auspices of the Council for Science, Technology and Innovation (CSTI) aims

at promoting challenging R&D, to which end it has incorporated several new mechanisms.

One such is the introduction of program managers (PMs) who play a producer role and are not responsible for R&D itself, but for the overall management of R&D, and for translating results into the creation of ground-breaking innovation. PMs have free rein with respect to the planning, execution, and administration of R&D, and after having brought in superior technology and personnel from outside, will be expected to construct systems involving competitive and cooperative relationships (such as by introducing the Stage-Gate method or organizing joint teams involving cooperation between academia and industry) and to promote programs oriented to achieving R&D targets.

Additionally, PMs will nurture research plans by taking time before the start of R&D to provide a period for formulating plans, as well as allowing for the possibility of adding new concepts in response to stimulus from external ideas and knowledge, for altering topics in accordance with new developments even after work begins, and even for aiming for even greater impacts by setting more challenging targets. Within such progress management, R&D outcomes are not evaluated solely from a third-party standpoint; support is also sometimes given through advice emphasizing the perspective of efforts in the context of R&D management. In the operation of such flexible research plans, it is extremely effective to manage disbursements through fund systems, which are able to provide funding to accelerate programs when needed and have the flexibility to deal with other unexpected factors.

In the future, with reference to the management experience that we have gained through ImPACT, which is significantly different from these conventional systems, it will be important to provide broad-based opportunities to attempt R&D that aims at the transformation of society by new ideas, without fear of risk, and to produce large numbers of personnel who aspire to dramatic innovation.

[C] Priority Initiatives

- To investigate and facilitate the spread of methods suitable to the promotion of challenging R&D, including investigating the introduction of awards systems to encourage research based in new media. [relevant ministries]
- To situate ImPACT as a pilot model of a new type of R&D support system and to facilitate its further development toward the creation of high-impact outcomes through continuous operational improvements. [Cabinet Office]
- To share the experience gained through the process of running ImPACT with the relevant ministries, and to encourage the development of programs to promote challenging R&D. [Cabinet Office, relevant ministries]

(2) Platforms for Realizing "Society 5.0" (The Super Smart Society) as a New Economic Social institution

[A] Basic Perceptions

In order to bring about Society 5.0 as a new social mode of production, it is important to move forward in a proactive and steady development of 11 systems[1] based on economic and social challenges, to promote collaboration and coordination between systems, and to build platforms that facilitate the creation of new values, including new services that have yet to be imagined. These platforms, as well as with regard to the technical aspects of realizing the advanced fusion of cyberspace and physical space, should also play a role in promoting the development of strategies, systems, and personnel for improving industrial competitiveness. Specifically, it will be necessary to engage from the following five standpoints: 1) developing databases as a foundation for the creation of new values and services, 2) promoting data utilization, 3) promoting intellectual property (IP) strategies and international standardizations 4) promoting regulatory and institutional reforms along with the cultivation of social acceptance, and 5) promoting capacity development and personnel training.

1) Developing Databases as a Foundation for the Creation of New Values and Services

With a view toward platform development, a decision has been taken to move forward with the development of the common databases that are necessary for improving sophistication and promoting step-by-step collaboration and coordination between the 11 systems mentioned above, as well as to encourage collaboration and coordination with still other systems. In this Comprehensive Strategy, it will be necessary to identify those databases and work steadily to address any challenges facing their development.

2) Promotion of Data Utilization

As we enter into an era of explosive data production with the full-scale shift to the Internet of Things (IoT), whether we are able to generate value by analyzing aggregate data will be the key to bringing about Society 5.0. Therefore, promoting R&D for that purpose should lead to its

[1] Optimization of energy value chains; the construction of a global environmental information platform; realizing efficient and effective maintenance, upgrading, and management of infrastructure; realizing a resilient society in the face of natural disaster; intelligent transport systems; new manufacturing (*monozukuri*) systems; integrated material development systems; systems for community living to foster a healthy nation; hospitality (*omotenashi*) systems; smart food chain systems; and smart production systems.

implementation at the societal level. In that instance, based on the current situation in which the spread of smartphones and other devices has led to an emphasis on personal data as being important for service development and provision, it will be important to investigate a mechanism for individual involvement in data circulation (system that enables individuals themselves to manage the parties to which their data is provided, etc.) as well as to enable broad-based and high-level data utilization. Recognizing that the quality, quantity, and circulation velocity of the data available for use by corporations and individuals are directly linked to corporate and national competitiveness, and especially to the convenience of individual lives, it will be necessary to create an environment that facilitates the aggregation, analysis, and distribution of various data while adhering to the premise of personal information protection.

3) Promotion of IP Strategies and International Standardization

With advances in technologies such as IoT, it seems likely that new types of information products will appear, such as databases of information automatically aggregated from, for example, sensors or inventions utilizing artificial intelligence (AI). For this reason, there is a need for the comprehensive consideration of the ideal form of next-generation IP systems designed to address such changes. In addition, IP strategies and the acquisition of global standards will be extremely important to efforts aimed at securing global competitiveness in relation to the IoT and other technologies, as well as successively producing new values and services. Furthermore, no matter how superior the technology that has been developed, market capture will be unlikely in cases where an open-close strategy is not appropriate, or where there is no compliance with international standards.

For this reason, international competition by states and corporations in relation to IP and standardization is steadily intensifying. Although a sense of urgency is essential to the acquisition of international standards, Japan has been noted for being slow in this area. Overseas, public research institutes, academic personnel, and corporate experts in standards and IP all participate in the formulation of international standards, and in some cases their activities are grounded in state or corporate interests. Japan has also been called on to respond more rapidly and to intensify activities by its companies, with support provided by its public research institutes. In this instance, rather than being passive, we should be more aggressive at seizing the initiative at the global level, such as by proposing international standards.

4) Promotion of Regulatory and Institutional Reforms and Cultivation of Social Acceptance

When introducing new goods and services through scientific and technological advances, situations may also arise in which existing legal systems work to inhibit social implementation. The

particular tendency in Japan, whereby activities that fall into legal gray areas tend to be disdained or shied away from, calls for the adoption of a stance that seeks to envision the shapes of new business models and industries emerging from science, technology, and innovation (STI) so as to anticipate regulatory revisions and the enactment of rules that will be considered necessary.

In addition, the promotion of "Society 5.0" will necessarily entail the sharing of the vision of its ideal society, and the formation of social consensus will be vital, particularly the shared recognition that it will result in more comfortable, high-quality lives for each and every citizen. For this purpose, it will be essential to carry out a multi-faceted examination of the various impacts and challenges that technologies will have on the social mode of production, and to seek out possibilities for regulations, institutions, and social customs that will help achieve both innovation and peace of mind.

5) Promotion of Capacity Development and Personnel Training

The implementation of Society 5.0 in advance of other countries will necessarily entail the training and recruitment of personnel to drive the requisite basic technologies. Particularly important in this regard will be the promotion and training of personnel in the fields of mathematics, data science, and statistical sciences and its related technology, which constitute cross-sectoral scientific and technological fields underlying the required basic technologies.

In addition, there is a possibility that many of the jobs that are now carried out by human beings will come to be automated through utilization of technologies such as the IoT, robotics, and AI, and it will be necessary for human beings to transition to other jobs with higher added value or that will have been newly created. Technological progress is swift, and working people will also be required to relearn skills in accordance with their individual abilities and expertise.

[B] Priority Challenges

1) Developing Databases as a Foundation for the Creation of New Values and Services

Under the 5th Basic Plan, Intelligent Transport Systems (ITS), optimization of energy value chains, and new manufacturing (*monozukuri*) systems have been selected as core systems for inter-system collaboration and coordination, while systems for community living to foster a healthy nation, smart food chain systems, and smart production systems are identified as other candidate systems. With a view to achieving collaboration and coordination between these systems as soon as possible, the plan calls for the establishment of mechanisms and the development of associated technologies that will enable broad-based inter-system utilization.

From the multiple specific systems combinations with high feasibility, as the requisite function for a shared foundation, the development of the following databases will be necessary. Among these,

the provision of a three-dimensional (3D) mapping information database should be proactively developed as a precursor of inter-system collaboration and coordination. It will be important to move ahead with implementation by collaborating with the Cross-Ministerial Strategic Innovation Promotion Program (SIP), making use of the results of the ImPACT program, and working in conjunction with the measures being implemented by the relevant ministries.

- **3D mapping information database**: Will store mapping information in a hierarchical structure, and be utilized by dynamically overlaying a base layer of infrequently updated mapping information (e.g., relating to roads and buildings) with layers of updated mapping information (e.g., related to traffic and population). Storing data relating to road conditions (e.g., damage) acquired by vehicles equipped with various types of sensors while making use of the 3D mapping information database for implementations such as autonomous cruising as a layer of infrastructural information will lead to increased efficiency in the maintenance of road infrastructure. In addition, by regarding vehicles as an energy source and making use of vehicle position information, they can be utilized in disaster reduction contexts as mobile energy sources in the event of a natural disaster.
- **A database facilitating the circulation of data between different industries**: Will be utilized in the creation of new value by combining data from multiple projects. For example, the analysis of procurement plans on the basis of data relating to parts and materials procurement and inventory management in multiple factories will enable the creation of optimal delivery plans in logistics contexts, leading to the creation of new values such as joint delivery services.
- **Global environmental information database**: Will be utilized in the creation of new information by effectively and efficiently combining data from a variety of sources, such as global observation data from satellite and oceanographic sources and climate change prediction data. Allowing for the shared use by research institutes, local governments, and corporations of global environmental information centered in the Data Integration and Analysis System (DIAS) will lead to value creation for agricultural production and disaster prevention measures that combine a variety of global environmental data and meteorological forecasts such as temperature, precipitation, and solar radiation amounts, as well as for other measures needed to prevent heat illness and infectious disease through the combination of data sources related to medical care.
- **People, goods**, **and vehicular information database**: By enabling the shared utilization of positional information relating to people, goods, and vehicles, this database will enable the creation of new services including those oriented to the provision of safe transit boarding

assistance and avoiding congestion in commercial facilities, as well as safe mobility support for wheelchair users.

- **Visual information database**: By linking publicly available visual information with systems such as surveillance cameras and video sharing services for the shared utilization of visual data, this database will lead to value creation in a variety of contexts including the use of human flow analysis in the optimization of tourist routes, community revitalization, the effective development of transportation infrastructure, and crime prevention.

As shared challenges for these databases to play as a common foundation, with regard to data format and interoperability, it will be necessary for all data to be appended with metadata relating to location and time, and to ensure that these databases will be able to view data from various sources in a logically integrated as well as universally accessible form.

Ensuring high-level security will be critical with regard to the development of these databases, and it will be necessary to promote the increased sophistication and social implementation of security technologies shared by all systems, as well as to build in functionality for implementing appropriate risk management. In other words, in addition to ensuring security for IoT-accessible devices, it will be important to promote R&D of cybersecurity technologies that will ensure information credibility, and check the safety of mechanisms and communication pathways by which multiple IoT devices carry out mutual authentication.

In addition, when providing goods and services, it will be important to engage on the basis of a philosophy of mission assurance, and the realization of security quality will also be essential. Expenses incurred in ensuring security quality are not costs, but investments that will create value. Two factors are important in the realization of such quality. The first is to have a “security-by-design” mindset that incorporates security considerations from the planning stages, with the aim of achieving comprehensive security for data and IoT systems based on the hierarchical structure of individual IoT systems during development and operation. The second is to aim for mutual cooperation between IoT systems when implementing interdisciplinary collaboration and coordination, so as to ensure security for IoT systems overall. Furthermore, coping with the ever-increasing sophistication of cyber-attacks will necessarily entail efforts to train personnel to ensure security. With regard to the promotion of increased sophistication and social implementation for security technologies, these must be addressed to critical infrastructure on a priority basis. Specifically, together with the promotion of R&D that relates to cybersecurity technologies, we need to construct mechanisms for achieving the standardization and automation of information sharing as it relates to cyber-attacks and other threats both inside and between industries, as well as to engage further in the creation of information-sharing environments that cross industry boundaries. Such efforts will also lead to advancements in the establishment of security operation centers (SOCs) that could conceivably be

set up for short periods on an event basis, as well as to promote the establishment of SOCs between industries.

2) Promotion of Data Utilization

When utilizing databases that have been played as a common foundation function and when establishing collaboration and coordination between multiple systems, it will be important to utilize data through the heightened sophistication of AI and other technologies. In such instances, the focused and proactive promotion of technological developments for realizing productivity improvements in the aforementioned feasible systems combinations will be crucial.

The basis for promoting data utilization, giving consideration to achieving a balance between data utilization and the protection of personal information, is to enable the utilization of data in real time in all fields in order to contribute further to the enhancement of industrial competitiveness. For this reason, steps need to be taken to ensure that data housed in various places (e.g., prefecture and local governments) are formatted with basic metadata, including time and location information, machine-readable, and organized in a database in which information is either collated or appears integrated in a logical fashion that facilitates its utilization by third parties. Such databases should, in principle, be open access, and their free access and free utilization should be encouraged, especially by small and medium-sized enterprises (SMEs) and startup companies, in order to lead to the creation of industry for the society of the future. To this end, it will be important to maintain recognition of the merits of the parties that provide data. While the facilitation of data circulation, in particular, is seen by business people as contributing to business efficiency and the development of new business, the use of data also enables individuals to take advantage of more fine-grained services, and can lead to the realization of safer, more secure, and more comfortable lifestyles. It will be important to work to ensure that all stakeholders come to understand that the promotion of data utilization will improve value for society as a whole. As a result, data provision should be promoted on the part of the national government, local authorities, corporations, and individuals in order to generate positive feedback that will lead to the creation of value from a vast pool of data. In addition, it will be necessary to promote harmony with international institutions in order to encourage the utilization of data at the global level.

3) Promotion of IP Strategies and International Standardization

It will be necessary to comprehensively examine the ideal forms for next-generation IP systems in response to the IoT and other technological advances.

In addition, the promotion of standardization will necessarily entail identifying zones of competition and cooperation for basic functions, as well as the formulation of strategies that take

into account the acquisition of both de facto and de jure standards, while also taking into consideration the propriety of the open-close strategy of Japan's national industry.

In particular, with regard to the standardization of platforms in Society 5.0, it will be important to formulate and share reference models for use in the identification of zones of competition and cooperation and ensuring mutual connections between systems. In these instances, it will be important to proceed with design in collaboration with overseas initiatives such as Industry 4.0 in Germany, Advanced Manufacturing Partnerships in the USA, Made in China 2025, and FIWARE in the European Union.

In terms of platform construction, it will be important to proceed with standardizations in areas, such as data formats and interfaces that will encourage data utilization between multiple systems. Moreover, it will be important to proceed in a stepwise fashion, building shared platforms that will be able to be used in a variety of services, including new services that have yet to be imagined.

4) Promotion of Regulatory and Institutional Reforms and Cultivation of Social Acceptance

It will be necessary to move forward with a variety of related initiatives that aim to promote sciences that contribute to the creation of appropriate regulations and institutions. These include strengthening social measurement functions that reveal social costs and impacts to society and the economy, protecting personal information, addressing challenges that relate to areas such as the responsibility of service providers and manufacturers, strengthening ethical, judicial, and social initiatives through interdisciplinary engagements aimed at social implementation, and investigating regulatory relaxation and institutional reforms that will make the provision and implementation of new services possible.

With regard to robots, especially, given the aspect that social implementations will serve to promote their further evolution and development, it will be necessary to carry out preliminary investigations with a view to social implementation, with reference to the development of social institutions that can be used with security.

5) Promotion of Capacity Development and Personnel Training

Advances in STI such as the IoT and AI can be expected to lead to major changes in production and employment structures, as well as other economic and social systems. Accordingly, together with working to deepen the recognition of the kinds of jobs that can only be done by human beings, even in society with advanced AI, such as developing concepts, producing businesses, and exerting creativity, it will be important to examine potential methods for developing capabilities that pertain to these jobs and ways of training personnel beginning from the elementary and secondary school levels.

In addition, beyond traditional human resources development, voluntary and proactive measures to tackle the training of personnel to be responsible for jobs in, for example, project management and new business creation through technologies such as the IoT are needed from industry in cooperation with universities and graduate schools.

[C] Priority Initiatives

1) Developing Databases as a Foundation for the Creation of New Values and Services (including SIP)

[Cabinet Secretariat, Cabinet Office, MIC, MEXT, METI, MLIT, MOD]

- As well as promoting the construction of 3D mapping information database as a precursor to SIP "autonomous cruising systems", to undertake the formulation of standard specifications and develop interfaces that are required for superimposing mapping information featuring high-precision relative positional relationships within a limited range with respect to the reference of absolute position, and also to examine systems collaboration and coordination with "ensuring cybersecurity for critical infrastructure", "infrastructure maintenance, upgrading, and management technologies", "strengthening resilient disaster prevention and mitigation functions", and "the optimization of energy value chains", and to promote their use in other fields. [Cabinet Secretariat, Cabinet Office, MIC, METI, MLIT]

- To promote collaboration and coordination between systems, as well as building databases in which data from various sources will be able viewed in a logically integrated form, to promote the standardization of data formats and data exchange. [Cabinet Secretariat, Cabinet Office, MIC, METI, MLIT]

- On the assumption that differences in data format and in the specifications required for each system, as well as systems and sensors will be updated, to formulate actionable reference models for systems design and sophisticated software technologies to facilitate functional modularity. [Cabinet Secretariat, Cabinet Office, MIC, MEXT, METI]

- In the context of critical infrastructure, to promote R&D of cybersecurity technologies that are able to confirm whether the control and communications devices that make up networks are configured according to specifications and have not been modified (i.e., their integrity) during their construction and operation, as well as whether they have been swapped out with unauthorized equipment during operation (i.e., their authenticity). In addition, to build mechanisms to realize the standardization and automation of information sharing as it relates to

cyber-attacks and other threats both within and between industries. (Including SIP).
[Cabinet Secretariat, Cabinet Office, MIC, METI, MLIT, MOD]

- To establish IoT testbeds to encourage social implementation through the technical validation and service verification of databases that constitute a common foundation function for collaboration and coordination between systems, and to promote demonstration projects to encourage R&D in partnership with private sector companies. [MIC, METI]

- For cases with the possibility of early social implementation, to promote measures and systems that will provide ongoing support to private sector activities, and to implement commercialization supports such as promoting the use of testbeds and providing funding support for advance pilot projects and technological development and demonstration. [MIC, METI]

(Targets to achieve by 2020)

- To develop a 3D mapping information database; a database facilitating the circulation of data between different industries; a global environmental information database; a population, commodities, and vehicular information database; and a visual information database.

- To build platforms based on a reference model and 3D mapping information database, and to promote their social implementation to create value of use cases.

- With regard to critical infrastructure such as communications and broadcasting, power, and transportation, as well as carrying out the social implementation of cybersecurity technologies built at SIP at the time of the 2020 Tokyo Olympic and Paralympic Games (hereinafter “Olympic Games”), to develop security confirmation technologies for IoT.

2) <u>Promotion of Data Utilization</u>

[Cabinet Secretariat, Cabinet Office, MIC, MEXT, METI]

- It will be necessary to promote the development of technologies for AI, big data analysis, and the integrated analysis of various data supporting the creation of new value through effective data collection and utilization by IoT technologies. [MIC, MEXT, METI]

- To promote the open availability of various data relating to topics such as medical care, education, and infrastructure in the position of national and local public bodies as machine-readable data in a form suitable for utilization in diverse fields. In addition, in order to achieve a balance between privacy and STI, to establish a foundation for the utilization of personal data while aiming at the protection of personal information and to promote such utilization. Furthermore, to undertake

continued efforts to clarify rules governing the handling of personal data from the standpoint of the protection of personal information. [Cabinet Secretariat, Cabinet Office]

- In order to establish an environment in which a wide variety of data (including personal data) is shared and utilized by society as a whole, in order to develop social awareness of the utility of data circulation and in order to promote data circulation, to promote the activity to make the private sector data available as open data, and to investigate a mechanism for individual involvement in data circulation (systems that enables individuals themselves to manage the parties to which their data is provided, etc.). [Cabinet Secretariat, relevant ministries]

3) Promotion of IP Strategies and International Standardization

[Cabinet Secretariat, Cabinet Office, MIC, MEXT, METI, MLIT]

- To promote collaboration and coordination between systems, as well as building databases in which data from various sources will be able viewed in a logically integrated form, to promote the standardization of data formats and data exchange, including high-precision metadata relating to location and time. At the time of such promotion, to implement strategic commercialization and standardization in an integrated fashion. [Cabinet Secretariat, Cabinet Office, MIC, METI, MLIT]
- On the assumption that differences in data format and in the specifications required for each system, as well as systems and sensors will be updated, to formulate actionable reference models for systems design and sophisticated software technologies to facilitate functional modularity. [Cabinet Secretariat, Cabinet Office, MIC, MEXT, METI]
- With regard to new information goods such as AI creations and 3D data, as well as databases for which creativity is difficult to recognize, to carry out a concrete study of the need for and nature of IP protections while paying attention to related aspects such as the value to be generated by making such goods available to the market. [Cabinet Office, METI]

4) Promotion of Regulatory and Institutional Reforms and Cultivation of Social Acceptance

[Cabinet Office, MEXT, relevant ministries]

- Along with identifying institutional challenges to new goods and services such as those promoting the utilization of AI and robots, as well as to the social implementation of business models (such as by categorizing them by whether they are safe or reassuring to carry out an examination of

how the challenges thus identified should be addressed by the state and other stakeholders, including such possibilities as institutional review or the formulation of necessary rules. Also, in collaboration with industry and the academic community, to engage in the comprehensive study of the social impacts and ethical conundrums stemming from advances in STI, including from the perspective of ELSI. As well as encouraging the participation of researchers in this study, to ensure that resource allocation is properly secured for such research in terms of both funding and personnel. [Relevant ministries]

To endeavor to strengthen social measurement functions that reveal social costs and impacts to society and the economy, to strengthen ethical, judicial, and social initiatives through interdisciplinary engagements aimed at social implementation, and to promote sciences that will contribute to the creation of appropriate regulations and institutions. [Cabinet Office, MEXT]

5) Promotion of Capacity Development and Personnel Training

[Cabinet Secretariat, Cabinet Office, MIC, MEXT, METI, MLIT, MOD, relevant ministries]

- To promote initiatives for encouraging the joint training by industry and academia for developing personnel who will be responsible for the creation of new businesses through technologies such as IoT. [Relevant ministries]
- To implement the human resource training (including SIP) as a means of ensuring cybersecurity against sophisticated threats. Also, to promote the training and recruitment of personnel in relation to cybersecurity, data science, and international standardization, including through overseas partnerships. [Cabinet Secretariat, Cabinet Office, MIC, MEXT, METI, MLIT, MOD]
- As well as endeavoring to extend the motivations, skills, and talents of young students through highly advanced science and technology, science and math education, and information literacy, to engage in the training of science and technology personnel that will play a leading role in future society by cultivating an awareness of the role of science and technology in society from an early age. [MEXT]

(3) Reinforcing Basic Technologies for “Society 5.0” (the Super Smart Society)

[A] Basic Perceptions

Working toward the realization of Society 5.0 will require the strengthening of the basic technologies required for platform building as well as the further strengthening of technologies in areas where Japan’s strengths lie, and these will form the core of new value creation in individual systems. In this instance, in order to progress spirally from basic research to applied research, and

then to development aiming at social implementation, it will be necessary to undertake the further enhancement of R&D systems involving industry, academia, and governments through the use of institutions such as Japan's National R&D Institutes (including the Designated National R&D Institutes).

The basic perceptions regarding the individual basic technologies specified in the 5th Basic Plan are as given below. It is also worth noting that achieving the human-centered society that constitutes Society 5.0 necessarily entails further investigation into the nature of humanity and society.

1) Cyberspace Technologies

- **Cybersecurity technologies**: In IoT systems, the fact that the lifecycle of technology is envisioned over the long term, from systems design up to the point of disposal, means that dealing with vulnerabilities and encryption strength will be important. In addition, with regard to the centralized and collective methods by which the huge numbers of IoT devices will be managed, costs will be significant, and in some cases security of the overall system cannot be ensured. The formulation of methods to achieve secure communications at a low cost will also be important.
- **IoT systems construction technologies**: In consideration of the fact that there will be connections to architecture that allows system updates while large-scale systems are in operation, as well as to both old and new IoT devices, virtual technologies that provide functionality at the edge or server side are essential.
- **Big data analysis technologies**: In addition to processing technologies that can derive knowledge and value from large-scale quantities of widely variable and sometimes unstructured data, R&D aimed at more sophisticated processing technologies (e.g., the introduction of real-time processing) will be necessary.
- **Artificial Intelligence technologies**: In addition to the development of innovative basic AI technologies that are able to solve problems, as exemplified by today's deep-learning technologies, we should promote R&D based on an integrated view of the entire field, including areas such as search-based AI, knowledge-based AI, measurement-based AI, and integrated AI.
- **Device technologies**: It will be important to develop technologies for achieving high speeds and real-time processing for large volumes of data in ultra-compact forms with ultra-low power consumption. It is also worth noting that, in the development of various types of devices, it will be important for information relating to desired functionality and

performance, as well as to the latest materials and device technologies, to be shared with parties on both the systems development side and the materials development side.

- **Network technologies**: While it will be obviously be necessary to promote network virtualization technologies, on the assumption that the huge numbers of IoT devices will feature wireless communication, it will also be important to establish technologies aimed at achieving higher levels of wireless access.
- **Edge computing**: With a view to the increasing speed of real-time processing, promoting the construction of distributed processing technologies and architecture that gives consideration to ensuring the security of gateways and other terminating units (or their lack thereof) will be important.

2) Physical Space ("Real Space") Technologies

- **Robotics**: Utilization can be expected in a variety of fields, such as communications, welfare and workplace assistance, and manufacturing (*monozukuri*). Accordingly, it will be important for Japan to come to grips with international contributions, such as by taking the initiative to get involved with the international standardization of safety evaluations and by continuing to play a leading international role with regard to safety standards.
- **Sensor technologies**: In addition to various other forms of information acquisition techniques, we should engage in the development of more sophisticated technologies for remote monitoring and implementing remote functionality updates.
- **Actuator technologies**: Should be promoted on the basis of considerations of basic research into technologies for reliable evaluation relating to mechanisms, driving, and control, as well as collaborations with AI research to create intelligent actuators.
- **Biotechnology**: In addition to promoting the development of technologies such as biosensors, biocompatible interface devices, and bioactuators, it will be important to engage in basic research into biotechnology more generally.
- **Human interface technologies**: Considering advances in individual devices and technologies, as well as in fields such as virtual reality (VR), augmented reality (AR), Kansei engineering (also known as affective engineering), and neuroscience, human coexistence with intelligent machines as typified by robots will also place increased importance on research into areas including differences in social acceptance, such as whether robots should be considered as equivalent to human beings or as their tools.

As technologies that provide cross-sectional and underlying support for the development of the cyberspace and physical space (real space) technologies listed above, it will be necessary to endeavor to reinforce efforts in connection with the following basic technologies.

- **Materials and nanotech**: It will be important to promote the development of innovative structural and functional materials that support areas such as energy, infrastructure, and health care, as well as to promote the development of more sophisticated components with application in these areas.
- **Photonic and quantum technologies**: In order to provide cross-sectional support in a wide range of fields such as information communication, medical care, environment, and energy, and to continue to contribute to the formation of the higher-order social and industrial infrastructure needed to meet social demand in various points such as accuracy, sensitivity, capacity, energy efficiency, and security, it will be important to promote basic and applied research oriented to the further advancement of measurement technologies, imaging and sensing technologies, information and energy transmission technologies, and processing technologies.

[B] Priority Challenges

With regard to the basic technologies required for platform building, we will continue to promote effective and efficient R&D while taking an integrated view of the entire field. In particular, engagements in the fields of cybersecurity technologies, big data analysis technologies, and AI technologies are important research subjects that could become a foundation for all technologies, and a special emphasis should be placed on engagements in these areas.

In addition, the collection of vast amounts of information from sensors and similar devices and its high-speed transmission, storage, and processing in cyberspace, as well as the real-world application of the results of information processing and analysis through actuators and the like, necessarily entail that we endeavor to strengthen cyberspace technologies such as network technologies, information processing technologies, and physical (i.e., real) space technologies such as robotic, sensor, and actuator technologies.

It is worth noting here that as technologies providing cross-sectoral and underlying support for these basic technologies, we are promoting advancements in materials and nanotechnology, leading-edge measurement technologies, and fine processing technologies, together with the early construction of Integrated Material Development Systems (see Chapter 2 (1) III.ii). In addition, in the strengthening of these basic technologies, it will also be important to adopt a medium-to-long-term perspective toward promoting basic research into more fundamental technologies. These include photonic and quantum technologies (which contribute to advances in measurement, imaging and sensing, information and energy transmission, and processing technologies), heat (phonon) control technology in the field of nanotechnology (which is important for advanced thermal

management), and biotechnology (which contributes to a variety of fields such as the advancement of measurement, diagnosis, and imaging techniques, as well as the creation of useful materials).

Innovative materials and products can only lead to social implementation after they are accepted by society. For this reason, it will also be necessary to engage in the construction of technologies and mechanisms for appropriately evaluating the safety and environmental impact of such materials and products.

In addition, with a view achieving the human-centered society that constitutes Society 5.0, it will also be important to pursue further technological development and deeper scientific research into areas such as cognitive science and neuroscience that relate to the nature of humanity and society.

1) Cyberspace Technologies

- **Cybersecurity technologies**: With an emphasis on vulnerability handling and encryption strength, it will be important to build trust and promote R&D into lightweight encryption technologies and other areas for possible implementation in IoT devices, in which features such as memory capacity, in particular, can be assumed to be limited.
- **Big data analysis technologies and AI technologies**: While fostering social receptivity to the aggressive use of AI by considering the nature of potential changes to society through the utilization of technology in areas such as people's lifestyles, the structure of industry, and modes of employment, it will be important to engage continually with this technology from the R&D stage to the social implementation stage.
- **Network technologies**: It will be necessary to build networks to accurately grasp explosive volumes of data from a variety of equipment in real time in order to perform sophisticated analysis and judgment. R&D into the sensor technologies and edge computing technologies that will be tasked with carrying out a share of analysis and judgment from a real-time perspective will also be necessary. In addition, high-volume storage and high-speed communications technologies that make use of photonics and other state-of-the-art technologies will also be important.
- **Information processing technologies**: In order to realize high-speed, large-scale information processing, the development of the requisite component technologies for building a foundation for quantum computing will also be important. This will include the development of 3D integrated circuits, as well as quantum devices and architecture.

2) Physical Space ("Real Space") Technologies

- **Robotics**: From a welfare and workplace-assistance perspective, we should promote technological developments that will contribute in areas such as safety and security in the lives of the elderly or persons with disabilities, or ensuring productivity in a variety of economic activities.
- **Sensor technologies**: We will promote the shift to higher performance and ultra-compact and ultra-low power consumption devices, and engage in the development of various types of sensors including biosensors that enable the collection of biological information. In terms of device technologies, the assumption that IoT devices will have long lifecycles and will not be supplied with power on a frequent basis entails the desirability of continuous efforts toward energy savings. R&D into areas such as high-capacity memory storage that make use of features such as spintronics and ultra-compact, ultra-low power devices will also be important. Furthermore, it will also be necessary to pursue developments in other areas, such as power sources for sensors and other devices, as well as power control technologies.
- **Actuator technologies**: We will pursue incorporation of such as micro-electro-mechanical systems (MEMS). In addition, we will promote the development of bioactuators.
- **Materials and nanotechnology**: It will be necessary to endeavor to continue strengthening the following technologies, which contribute to the further advancement of individual systems (e.g., the optimization of energy value chains):
    - Power semiconductor technologies that will lead to high-efficiency power controls
    - Catalyst technologies that will contribute to process innovation
    - Materials technologies such as biomaterials and structural and functional materials that possess new functions and features

[C] Priority Initiatives

1) Enhancing Basic Cyberspace Technologies

[Cabinet Secretariat, Cabinet Office, MIC, MEXT, METI, MLIT, MOD]

- To promote R&D from innovative basic research to social implementation with a view to evolving self-aware AI that can grasp its own features. In addition, as well as promoting neuroscience and even more innovative AI-focused R&D, to provide R&D outcomes arising from ministerial partnerships to the relevant ministries and agencies, and to drive the creation of further new industries and innovations and the enhancement of international competitiveness on the part of the government as a whole. [Cabinet Office, MIC, MEXT, METI]

- To promote the building of trust through R&D into technologies for providing not only conventional authentication for individuals and organizations but also low-cost authentication for the very IoT devices that are expected to proliferate in future. (Including SIP) [Cabinet Secretariat, Cabinet Office, MIAC, METI, MLIT, MOD]

- To promote R&D of network technologies such as edge computing, virtualization, and processing optimization for the real-time processing of large-scale data, as well as big data analysis technologies that will carry out the high-speed and high-precision extraction of knowledge and value from data. [MIC, METI]

(Targets to achieve by 2020)

- The production of innovative basic technologies outcomes to support cyberspace platforms.

2) Enhancing Basic Physical Space ("Real Space") Technologies

[Cabinet Office, MIC, MEXT, MHLW, MAFF, METI, MOE]

- To promote R&D into areas such as robotics applications that will contribute to improved productivity in manufacturing (*monozukuri*) fields and the service sector, as well as support robots oriented to providing safety and security in the lives of the elderly or persons with disabilities. [MIC, METI]

- To develop ultra-compact, ultra-low power devices (including sensors, actuators, and semiconductor devices). [Cabinet Office, MEXT, METI, MOE]

- To develop and demonstrate nanotech and materials technologies that will support individual systems. [Cabinet Office, MEXT, METI, MOE]

- To undertake device development, nanotechnology and materials development, and the development of integrated material development systems, fine processing technologies, and leading-edge measurement technologies that will provide a foundation for a wide range of fields such as the life-sciences and technologies relating to power saving and the environment. [Cabinet Office, MEXT, METI]

- To pursue advances in quantum beam utilization technologies such as state-of-the-art lasers that will be central to the creation of new industries and technological foundations, as well as to enhance the research base in fields such as photonic and quantum technologies, including the development of imaging and sensing technologies that go beyond the limits of conventional precision and sensitivity, and optical electronics technologies that carry out high-speed, low-

energy information processing by converting electronic signals to optical signals. [MEXT, METI]

- To enhance biotechnological R&D that includes the creation of new value through advanced use of biological functions relating to agriculture [MAFF]
- With a view toward social implementation, to examine technologies and mechanisms for appropriately evaluating the safety and environmental impact of materials and products. [Cabinet Office, MEXT, MHLW, MAFF, METI, MOE]
- To promote the commercialization of fields in which Japan has been strong, such as VR and AR.

(Targets to achieve by 2020)

- The practical application of ultra-compact, ultra-low power devices
- The development of component technologies related to quantum information processing and quantum information communications
- The full-scale practical application of the next-generation power electronics
- By around 2030, the practical application of innovative catalysts and related technologies for producing key chemical products
- By around 2030, the improvement of energy use efficiency in transportation equipment (e.g., automobiles and aircraft) by dramatically reducing the weight and extending the longevity of structural materials
- The commencement of operations for prototype systems, especially integrated material development systems
- The practical application of the production of useful materials making sophisticated use of biological functions

3) Efforts toward the Realization of a Human-Centered Society

- To carry out further investigations with regard to approaches to the clarification and study of the nature of humanity and society.