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Plenary Session 2

Areas and Visions for Setting Moonshot Goals

Vision Paper

I: Moonshot Research and Development Program

The Moonshot Research and Development Program is a new R&D program of the Japanese Government designed to be an ambitious and goal-oriented program with multiple grand challenge missions. Goals and missions are defined to be audacious, widely appealing, concrete, and addressing issues of global importance. Accomplishing the missions require development of a range of technologies and reformation of social frameworks. The program is not merely a science and technology research program. It is a program for techno-social innovation.

The motivation behind this program is the sense of urgency. Our society faces various challenges such as aging population and declining birthrate in developed countries, large-scale natural disasters, global climate change, and depletion of some of scare resources. Some even call these an "existential threat" to human beings. We are pressed with needs for creative and often disruptive solutions to problems. The Moonshot Research and Development Program was designed to drive our efforts to tackle the formidable problems we are facing as well as to develop technological platform to accelerate disruptive scientific research in the coming decades.

While "Moonshot" was inspired by the Apollo Project of the U.S. space program in the 1960's, we consider the Moonshot program in the 21st century needs to be redefined predominantly as a Techno-Social Grand Challenge. Most problems we are facing are not merely technical issues; they require a reformulation of social frameworks that involves changes in policy directives, legal frameworks, public acceptance, and business models in private sectors.

The Moonshot R&D Program is designed to be a long-term project, as opposed to the Apollo Program which was about 10 years, because the solution to many of issues we are facing today requires not only extensive technical and policy efforts, but also require emergence of a series game changers in various aspects including a series of scientific discoveries, technical breakthroughs, and operational innovations yet to be seen. Therefore, the program is largely designed to be the hybrid of engineering projects to push the boundaries of current

technologies to gain early outcomes of the project, a directed research serving as a foundation for further R&D for more fundamental and disruptive outcomes, and multi-stakeholder partnership development enabling deployment and social transformation at global scale. It should be made clear that the Visionary council assumes that the first 5 years are mostly focused on an extensive engineering integration of platform development, and a successful project will continue to be funded over 10 years. It is also assumed that substantial funding for blue sky basic research is required to fully accomplish most of the moonshot goals. Goals and missions of Moonshot R&D Program, drafted by the Visionary Committee, reflect such a recognition and design principles.

II: Areas and Visions for the Moonshot Program

The visionary council was assembled representing experts and multiple stakeholders to define overall architecture of the Moonshot R&D Program as well as proposing a set of goals and missions. Intensive discussions through a series of meetings to compile an initial list of possible goals reflecting ideas proposed through an open call from the general public, selected members from major ministries, and that of the visionary council. As a result, the visionary council proposed 25 goals grouped into three major theaters of campaign that is termed “Mission Area”. The first two mission areas address urgent issues for Japan (a rapidly aging society) and for the world (sustainability in the context of resources, climate change, biodiversity, and waste handling). The third mission area focus on technology development and deployment to accelerate scientific discoveries (particularly in life sciences) and exploring frontiers of next generation technologies (quantum computing and AI / Robotics). Twenty-five (25) goals and missions have been proposed from the visionary council. (See Appendix). Some missions can be initiated immediately, while others require further investigation to define concrete goals and execution plans.

The Moonshot program in the first two mission areas are supposed to turn around the situation with a radical solution and technical breakthroughs inspired from truly disruptive and extreme ideas. The third mission area shall unleash imagination of researchers to push the boundaries of technology.

The visionary council wishes the Moonshot Program triggers to unleash imaginations and change the mindset to leverage seemingly difficult situations into golden opportunities to transform Japan and the world. Obviously, it is not an easy task and requires imagination and determination. Perhaps it demands extreme solutions.

Japan is not short of wild imaginations. From the legendary “Astro boy” and classical “Gundam” to highly avant-garde “Ghost in the Shell”, imaginations and futuristic visions are recognized globally and imprinted into the mind of scientists and engineers. The fact that the Tokyo bay area was chosen as a scene of the first ever Cyberpunk novel “Neuromancer” by William Gibson is highly inspirational. In the moonshot program, we should push our imagination to the extreme and make it happen in reality. We only need to determine ourselves to do that. It is critically important for leaders commissioned to achieve each goal shall be empowered by a sufficient authority and resources to manage the project.

Goals proposed by the visionary council are highly interrelated reflecting the complexity of the issues as well as cross applicability of technologies. A brief explanation of the rationale behind choosing three areas and expectations for some of goals shall be described below.

1. Leveraging the Aging Society: Turning the aging society into the innovative and sustainable society by harnessing diversity through techno-social transformation

Rapid demographic change, notably an aging population with a declining birth rate, is seriously affecting Japanese society and industries. Labor shortage, progress in regional depopulation and deindustrialization, and fiscal pressure associated with the increase of social welfare spending are generally perceived as major issues that may undermine future of Japan.

The visionary council, however, viewed the situation as a golden opportunity to transform the socio-industrial structure of Japan to be a society with diversity in all aspects, high medical Quality of Life, and adapting disruptive industrial changes for productivity and sustainability.

Society 5.0 aims at a sustainable and inclusive society in which people with diverse background and conditions (such as age, nationality, gender, disabilities,

and living locations) can pursue their desired and diverse lifestyles. In this moonshot program, we aim at building technologies that augment human capabilities in various aspects, and a platform to deliver such capabilities to destinations desired (physically and virtually). Cyborg & Avatar technologies shall be one of the next generation platforms to make Society 5.0 into reality. Human augmentation and shared autonomy telepresence will be critical technologies for Society 5.0. The ultimate cyborg requires technologies to integrate the human body and man-made devices, most likely to be mechatronic devices with persistent neural links, that shall significantly augment human capabilities both physically and cognitively. Avatar in the future will enable us to virtually present in distant places and perform most of daily work with mixed autonomy robotics system, and such Avatars shall be able to work collaboratively with humans and other Avatars at large scale.

In short, we should imagine the future technologies (some with major scientific discoveries yet to be seen) as envisioned in "*Ghost in the Shell*" can be realized and deployed to make the sustainable society with diversity and inclusion.

While Cyborg and Avatar are a human-centric approach, a robot-centric approach is also important to compensate for labor shortage. Lack of labor force is an opportunity to accelerate automation. We push it to the extreme; no-humans-in-the-field. This may lead to zero accidents, zero noise, and highly productive construction. It may enable us to design and construct a shape of architecture that is not possible today. Fully automated construction, for example, requires the entire cycle of architectural and interior design, construction process, material procurement and delivery, and monitoring and inspections to be fully digitized and interlinked in a single platform where a group of various forms of robots operate according to the dynamically scheduled instructions. The prime contractors will be transformed into the digitalized process management and robot operators. Imagining the extreme on no-humans-in-the-field industry may enable us to redefine industries.

At the same time, practical deployment of such robotics system demands sophisticated interaction with humans. Principles and technologies to enable highly functional, intelligent, and collective robotics to interact with a group of people in various tasks, from mission critical tasks to everyday affairs, shall be explored.

Robotics systems and technologies can be used as robotics components of Cyborg & Avatar systems.

Biomedical sciences impact not only personal happiness but also increased participation in society. Transforming the modality of wellness and medical practice by creating data- and model-based personalized predictive, pre-emptive, and personal wellness to improve Quality of Life, and to develop a series of non-traditional means of intervening, including potential neuro-reprogramming, is a formidable challenge. Development of such technologies, combined with progress of biomedical sciences, enable us to better control a healthier state, to help us to prevent outbreak of diseases and deterioration of psychological and physiological status, thereby people can spend happier and more active lives. Technologies and service infrastructure shall be designed to benefit people of all ages, from infants to the elderly.

Another technical and societal challenges are to develop a system, including devices, services, and medical actions to significantly improve universal medical access of different degree for each region. It may include means to improve survival rate in emergency care through controlling metabolic level, remote and often AI-based medical diagnosis, and possibly (semi-)automated surgery that are all related to improve quality at point of care and extend capability to provide such medical practices beyond current limitations of time and space.

2. Save the Earth and our Civilization: Recovery for global environment and growth of civilization Saving the earth and our civilization with radical countermeasures

Since the industrial revolution, the human species has been exploiting natural resources of the earth and built the current affluent material civilization we live in. However, this has led to a steady deterioration of the global environment; if this situation is to continue, the human species may not even able to continue to survive on earth (acceleration of the dawn of the Anthropocene epoch).

Despite numerous international agreements signed so far, global climate change and resource deprivations pose clear and present threats to the survival of human civilization. Radical measures to significantly reduce our resource demands and means to restore environments and biodiversity has to be taken with technical

break through and sociological transformation.

Our load on earth has to be significantly reduced, not only to reduce the discharge of CO2, but also to reduce resource demands drastically at all aspects including energy, water, and materials. Not only reducing primary resource demands, removing and recycling wastes already dumped, particularly ocean plastic waste, is extremely important. If we are to aim at fully circular economy, we should be able to “resourcify” what is now considered “waste” into high valued resources. In an extreme scenario, Japan shall be importing waste around the world, resourcify them, and export them as high valued commodity.

Food is another issue that requires attention. Agriculture must be robust, resilient, and promote biodiversity. The extreme end of such an idea is to create and deploy technologies known as terra-formation. The visionary council envisioned radical departure from the traditional approach of incremental improvement of the food production, distributed, and recycling process to disruptive and sustainable transformation of industrial practices where both food supply and biodiversity can be enhanced simultaneously.

For such efforts to be effective, a formation of a global alliance that actually work is essential and expect Moonshot Program to lead the initiative on this aspect. While most climate accords focus on regulatory aspects, alliances to be formulated from the Moonshot Program shall focus on the proactive creation of industries based on a new paradigm emerging out from the program.

3. Exploring new frontiers of science and technology

The third area of Moonshot program seek to explore the frontiers of science and technology, initially in the area of life science, quantum computing and AI/robotics. In the life science area, some of Moonshot goals are proposed to develop next generation, high precision, comprehensive, and automated measurement systems and their data analysis platform and applied to fully map entire neural systems with special focus on peripheral nervous systems and their adjacent tissues such as gastro-intestine system and immune systems. Technologies and data resource developed shall accelerate biomedical sciences to understand the principle of life and to discover the cure of many diseases. Such efforts shall be interlinked with on-going projects such as Human Cell Atlas project and The Brain Initiative. Discoveries can be feedbacked to Cyborg project where neural connections both from CNS and the peripheral system into the electromechanical system integration as well as multi-party or cloud neural connections.

Performing projects of this magnitude requires an experimental system that enables us to observe what was not possible before. The visionary council expects such a program to induce singularity in science and technology by automating experiments and data analysis at the large-scale as well as the process of scientific discovery itself. The visionary council believes that scientific discovery by AI is one of the most disruptive and critical goals proposed in the Moonshot Program.

The visionary council considers this is a rare opportunity to invest extensively on the technical platform to create the foundation of next generation life science and medicine and jointly develop technologies, data and analysis platform, and collect base data for a range of model animals that cannot be performed by regular funding programs. Technologies and resources developed through the program shall accelerate basic research in broad areas of life science and medical research programs. Therefore, the major focus shall be placed on development of the technology platform and base data collections at larger scale. The program shall be interlinked with basic life science and biomedical research already funded by regular research programs to ensure feedback and early applications of technologies and resources. The visionary council has been very careful not to make goals implying to find cure for diseases, because we cannot commit to discover cure for diseases within the limited time span and milestones. What can be committed is technology and resource development to accelerate studies that may eventually find cures for diseases.

There are numbers of areas where such technologies make a difference in biomedical sciences. For example, the externalization of the complete reproductive process of human and other major model organisms can be a significant goal of the program with serious implications. While it requires a series of scientific discoveries to achieve it, focused research program with substantial technology development will be sure to accelerate the research and enables insights and technologies to be transferred to clinical practices including reproductive medicine, developmental disorders, and regenerative medicine. In addition, projects in the areas of artificial hibernation could be a major breakthrough in neuro-metabolic and immune control where early scientific insights and technologies to control them shall have broad applications from

emergency care and the food industry to deep space exploration.

Quantum computing and space robotics are critically important area where a range of audacious goals can be defined and transform industries as well as accelerates scientific investigations to explore our frontiers. Development of devices and software enabling quantum sensing, communication, and computing enable us to measure, transmit, and process information in ways we have not done before. Space robotics aims at creating software-driven reconfigurable robotics systems that work collectively at orbit, surface of Moon and Mars, and deep space. It shall be designed to be the game changer in space exploration.

III: Conclusion

The visionary council proposed 25 goals in three areas to be catalysts of transformation of approach to the problems we are facing and to explore new horizons of science and technology. These challenges are formidable. However, it provides us with an opportunity to create a new set of technologies, scientific discoveries, and to transform society toward a better world. We should all remember what Steve Jobs said; “the people who are crazy enough to think they can change the world are the ones who do”.

Appendix: Proposed Moonshot Goals

The visionary council was assembled representing experts and multiple stakeholders to define the overall architecture of the Moonshot R&D Program as well as proposing a set of goals and missions. Intensive discussions through a series of meetings to compile an initial list of possible goals and missions reflecting ideas proposed through an open call from general public, selected members from major ministries, and that of the visionary council. As a result, the visionary council proposed 25 goals and missions grouped into three major areas:

1. Leveraging the Aging Society: Turning the aging society into the innovative and sustainable society by harnessing diversity through techno-social transformation
2. Save the Planet and our Civilization: Recovery for global environment and growth of civilization
3. Exploring new frontiers of science and technology

The first two areas address urgent issues for Japan (a rapidly aging society) and for the world (sustainability in the context of resources, climate change, biodiversity, and waste handling). The third area focus on technology development and deployment to accelerate scientific discoveries (particularly in life sciences) and exploring frontiers of next generation technologies (quantum computing and AI / Robotics).

Area 1: Leveraging the Aging Society

- Turning the aging society into the innovative and sustainable society by harnessing diversity through techno-social transformation-

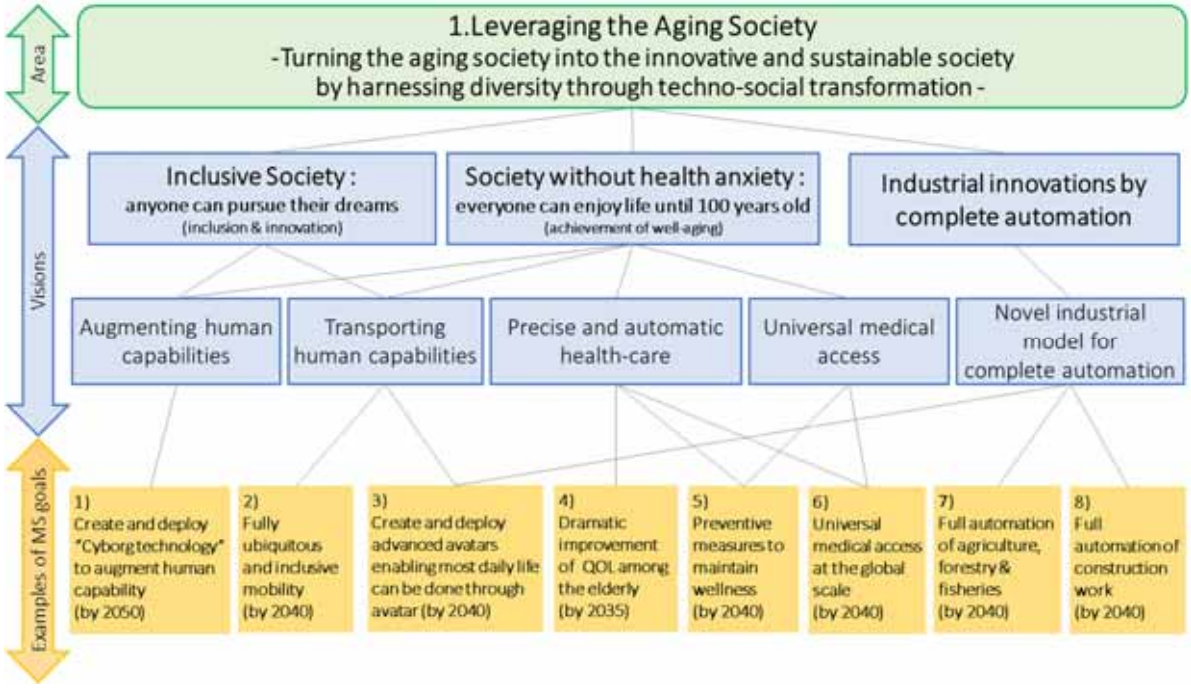

Fig.1 MS Area1, Vision and Goals

The visionary council proposed the following Moonshot Missions for Area1.

	Proposed MS Goals	Detail of goal & examples of R&D
1	Create and deploy "Cyborg technology" to augment human capability (by 2050)	Establish technologies to augment human abilities that allow everyone with diverse backgrounds (age, gender, nationality, handicaps, locations, etc.) to explore their potentials and pursue their desired lifestyles. The ultimate cyborg technologies require integration of robotics (metal/silicon-based and biological) and living tissues so as to augment perception, cognition, motor skills and so on that have deteriorated by aging. Near term goals shall target a range of human augmentation technologies of varying levels of integration from wearable device and

		exoskeleton to partial embedment of device to the body to BMI. In short, this mission aims at creating technologies part of which is shown in “Ghost in the shell”, but used to explore a better world.
2	Fully ubiquitous and inclusive mobility (by 2040)	Realize the inclusion of “mobility” that allows anyone to choose the optimal mobility service from anywhere on a smartphone, anytime and anywhere, by automating and integrating all transportation services (including public transport services like trains and buses, cars and bicycles, wheelchairs, personal transporters, manned drones (flying taxis), ships). This will alleviate urban congestion, provide safe and inexpensive travel for the elderly, and realize safe and comfortable transportation that meets all needs such as securing means of transportation in remote islands, depopulated areas, as well as conducting emergency rescues during disasters.
3	Create and deploy advanced avatars enabling most daily life can be done through avatar (by 2040)	To allow one to behave beyond the space-time and physical constraints through avatars and robots. For example, one can remain in Japan while going on a world trip using one’s avatar, work comfortably from anywhere, or even for people with physical limitations (such as ALS) to work/participate in the society without having them feel their physical limitations. To also bring people around the world together through language translation/interpretation anytime anywhere, and allow them to communicate with each other as if they were in the same space. It is important to envision very large numbers of Avatars being controlled by a handful of human as well as human-avatar collaboration at large-scale to be practically deployed in the future.
4	Dramatic improvement of QOL among the elderly	Elucidate the development mechanisms of various syndromes that lower QoL and develop technologies to expand and complement human abilities/functions, to dramatically reduce the

	(by 2035)	deterioration of QoL with aging so that people can stay active and healthy beyond the age of 100.
5	Preventive measures to maintain wellness (by 2040)	To maintain health, we not only expect behavioral changes from individuals (such as exercise and control food intake), but also come up with various solutions where people can work on maintaining their health and disease prevention without being aware of it. For example, to provide overwhelmingly delicious diet meals and menus, and creating AIs and robots that support individual health by predicting physical disorders and stress.
6	Universal medical access at the global scale-- Medical treatment everywhere and for everyone (by 2040)	Ensure that advanced medical services are always available to anyone in Japan and anywhere in the world. For example, to enable people living in rural areas to be seen by famous physicians in distant places, and for prescription drugs to be delivered to the patients anytime, anywhere in the world. Or, during large-scale disasters, physicians from all over the world can work together through holographic avatars to provide remote emergency first-aid to victims.
7	Full automation of agriculture, forestry & fisheries (by 2040)	Fully introduce and incorporate AI and robots into the agriculture, forestry and fishing fields or sites that require many years of experience and manual labor so that the robotic agricultural machines can capture all sorts of information via their sensors while automatically determining the optimal cultivation method and so on that is suitable with the surrounding natural environment, as well as construct a fully automated system that performs agricultural work in a precise manner. This will allow us to adjust the conditions that allow various management groups such as young people, companies, and venture companies that have no experience in farming to enter the industries, dramatically improve productivity and sustain domestic agriculture, forestry and fishing industries, as well as develop new agricultural solutions overseas.
8	Full automation of	Based on the procurement status of construction materials and the surrounding environment (noise

	construction work (by 2040)	problem), the construction robot will determine the optimal construction process and method, and establish a completely unmanned construction system that automatically manages the construction work. This will eliminate labor shortages and dangerous work at construction sites and create a smart construction industry free from noise problem. Our aim is to integrate this system with satellites and remote control systems using 5G to expand the Japan's construction industry in other countries.

Area 2: Saving the Earth and our Civilization

- Recovery for global environment and growth of civilization-

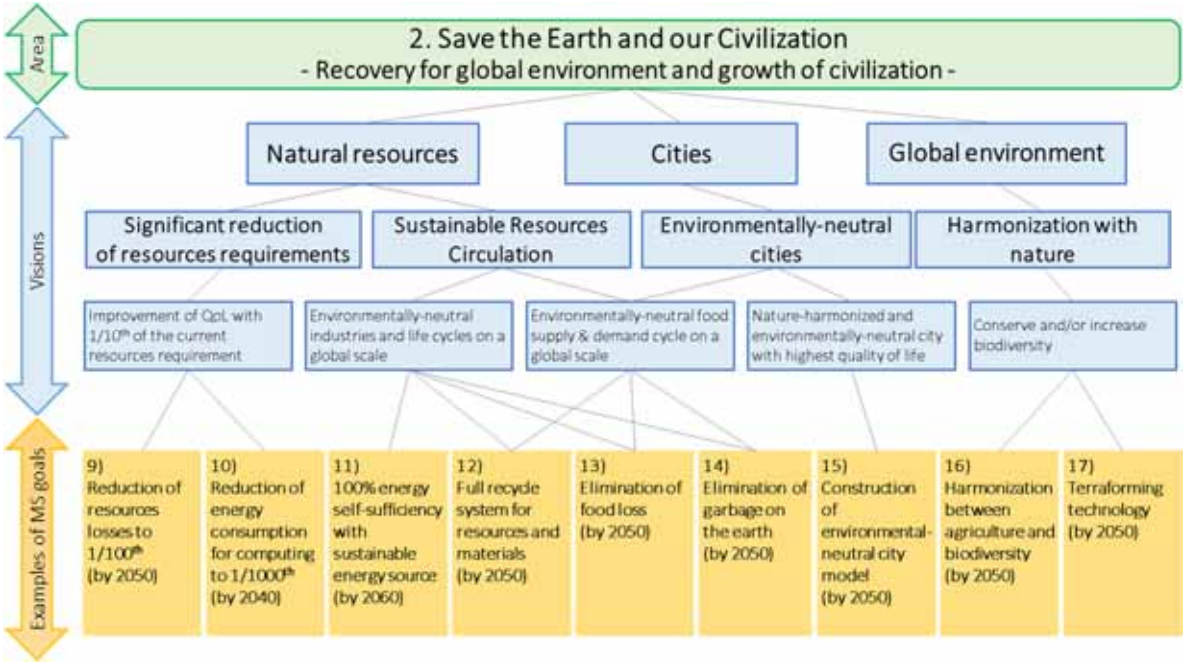

Fig.2 MS Area2, Vision and Goals

The visionary council proposed the following examples of MS goals for Area2.

	Proposed MS Goals	Detail of goal & examples of R&D
9	Reduction of resources losses to 1/100th (by 2050)	We are completely surrounded with industrial products that are getting smaller and lighter; yet the the scale of the factories that manufacture them and the supply chain of materials and parts are getting increasingly larger. Today, many of the input resources are discarded before they even get converted into products. We therefore want to develop innovative technologies that will radically transform the industrial production processes and reduce these resource losses (input resources not used for products) to less than 1/100.
10	Reduction of energy consumption for computing to	As the rate of progress in "Moore's law (performance improvement by miniaturization)" – that has supported the exponential improvement of computing power (information communication data

	1/1000th (by 2040)	processing) thus far – reaches its limit/saturation, we will establish a new paradigm in the near future (such as non-volatilization of logic components using spintronics) to realize large-scale data processing performance at a pace of “doubling in 2 years = 1000 times in 20 years”. For example, if we can develop a non-volatile microprocessor using a spintronics integrated circuit, we can reduce power consumption by two orders of magnitude or more and yet double the computing performance or more from the conventional level.
11	100% energy self-sufficiency with sustainable energy sources (by 2060)	To maximize the use of natural energy such as solar energy that has not been fully applied thus far, we aim to establish innovative power generation technologies (such as new solar power generation systems that use the entire range of wavelength of sunlight, or making use of the power generation capacities of microorganisms) as well as distributed grid technology to store and convert these energies. Our aim is to establish a fully self-sufficient energy system by implementing it on a large scale throughout society.
12	Full recycle system for resources and materials (by 2050)	Establish a system for turning wastes, pollutants, useful resource contained in a very small amount in the atmosphere (e.g. metals, nitrogen compounds, phosphorus compounds, and CO2), and garbage into resources without emitting CO2. Create an economic system in which the idea of “waste” is eliminated with everything being totally recycled.
13	Elimination of food loss (by 2050)	Deliver food to people who need it, efficiently and without loss or redundancy, based on real-time knowledge of stock levels and distribution/sales status throughout the entire food chain, from production to distribution, processing, and sales/export, by leveraging dynamic pricing system (in which prices will be continuously adjusted based on the supply/demand balance of agricultural produces, transportation distance, and other factors through the use of AI). Create a total solution for building a zero food-loss society by developing super species that can be produced in the right

		amount whenever they are needed, as well as establishing a system for recycling all left-over food and agricultural/forestry/fishery byproducts into animal feed/fertilizer/energy source.
14	Elimination of garbage on the earth (by 2050)	Develop alternative materiel for plastics to eliminate plastic waste from earth. Also organize a global competition, gathering businesses from Japan and elsewhere, to introduce technologies for automatically retrieving plastic garbage from land and sea, and turning them into resources. Leverage global waste problems to establish and build new industries.
15	Construction of environmental-neutral city model (by 2050)	Establish a new infrastructure solution that does not depend too heavily on hardware to lead a happy life in harmony with the natural environment, creating a model for environmentally neutral cities. This approach would be particularly relevant to developing countries where citizens are continuously moving to large cities. Japan can also apply the achievements gained through the development of this solution toward, addressing the issues of renovating the country's old and crumbling infrastructure and maintaining the infrastructure in rural depopulating areas.
16	Harmonization between agriculture and biodiversity (by 2050)	Move out from monoculture optimized for producing single crops efficiently, establish an ultimate form of sustainable agriculture based on regional climate and terrain, with minimal impact to natural environment. This approach should be widely shared with developing countries and the rest of the world to sustain and grow agriculture and biodiversity at the same time.
17	Terraforming technology (by 2050)	Desertification and rising sea levels exacerbated by climate change will destroy habitats in many regions. Develop new habitats by establishing technologies for restoring natural environment.

Area 3: Exploring new frontiers of science and technology

- Recovering our civilization and healthy global environment-

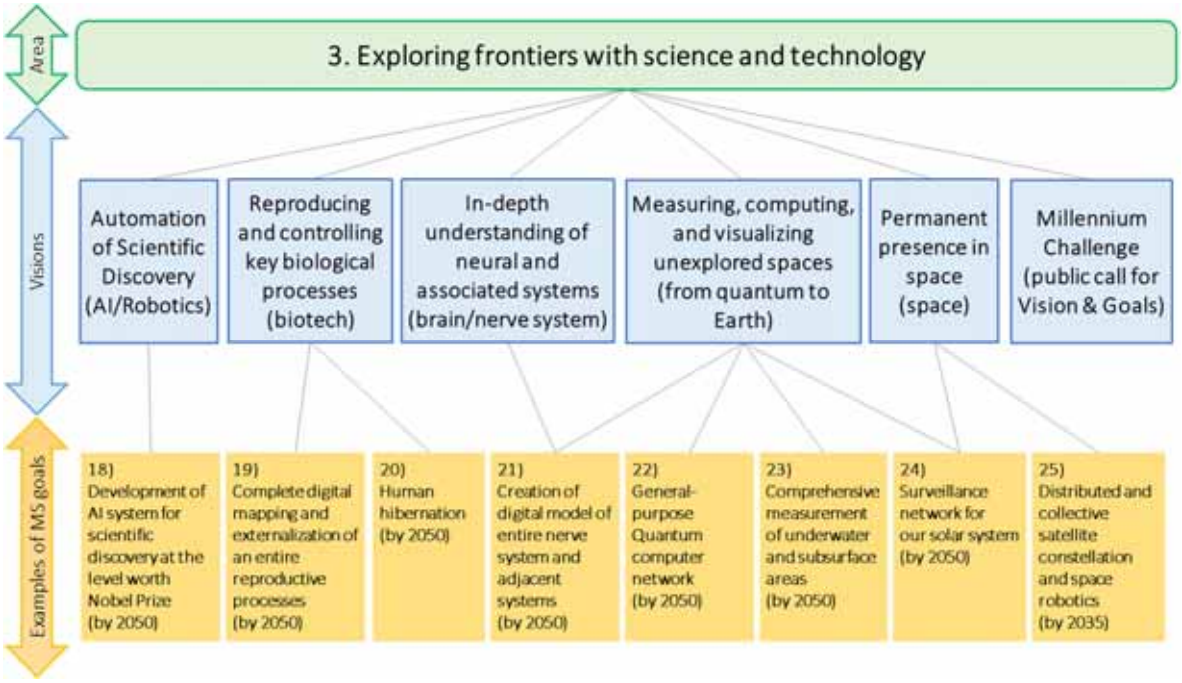

Fig.3 MS Area3, Vision and Goals

The visionary council proposed the following examples of MS goals for Area3.

	Proposed MS Goals	Detail of goal & examples of R&D
18	Development of AI system for scientific discovery at the level worth Nobel Prize (by 2050)	Build an automated system that will continuously make outstanding scientific discoveries (of Nobel Prize levels) beyond human capabilities by extensively introducing AI and robotic technologies to biomedical and biotechnology research. The repetitive cycle of formulating and validating hypothesis in this field can be augmented by AI autonomously building hypothesis from vast amount of test data and by robots automatically carrying out experiment tasks. This approach can lead to other achievements in the field of life and medical science, i.e. building a platform for developing next-generation experiment instruments and medical devices, and establishing a massive

		database for the life sciences.
19	Complete digital mapping and externalization of the entire reproductive processes (by 2050)	Long-range and directed research on the process reproduction and development of human and diverse model organisms to build digital models and develop technologies to control the process. One major target is to establish technologies to complete the entire reproduction cycle externalized. This approach can also help development of drugs used for diagnosing human genetic diseases and improve the success rate of infertility treatments. Also, it can be applied to recover extinct species.
20	Human hibernation (by 2050)	Discover the mechanism controlling metabolism, homeostasis, and sleep of hibernating animals to establish technologies for artificial hibernation and homeostasis control. This will enable the extension of biological lifetime during space travels over many light years.
21	Creation of digital model of entire nerve system and adjacent systems (by 2050)	Achieve total digital mapping of brain, the entire network of peripheral nervous system, together with associated systems (including gut tissue and lymphatic vessels) of several species including humans. The resulting technologies for comprehensive and highly precision measurements can be applied to accelerate various basic research in the life sciences. Gathered data will also help understand emerging topics such as the interaction between brains and the gut, the nerve system's control over the immune system, the effect materials transported in nerve fiber through the gut have on dementia and depression. In addition, it should shed light on how to make stable and long-range neural links for Cyborg research. The project will be linked with Human Cell Atlas project, the Brain initiative, and other international efforts.
22	General-purpose Quantum computer network (by 2050)	Develop general-purpose quantum computers, quantum software, and new algorithms to solve math problems that cannot be calculated fast enough with the Von Neumann architecture. This

		will enable the identification and development of functional material and useful macromolecular compounds, as well as dramatically improving AI functionality and accuracy.
23	Comprehensive measurement of underwater and subsurface areas (by 2050)	Establish technologies for seeing through sea water and ground surface accurately and comprehensively to understand underwater/underground geographical information, ground structure, crust/fault conditions. This can kickstart new business utilizing underground space based on advanced geographical information. These technologies will also enable early earthquake/tsunami warnings and fishery resource explorations.
24	Surveillance network for our solar system (by 2050)	Build a Space Situational Awareness (SSA) system for continuously monitoring asteroids and other bodies in the Solar System and taking/sending back extraterrestrial species to the Earth. Establish infrastructures aimed at extending space usage. This approach will enable space traffic management (STM), space weather forecast, exploration of the Solar System's boundary and deep space, extensive explorations of the inner planets, and future migration to other planets.
25	Distributed and collective satellite constellation and space robotics (by 2035)	Develop multi-functional robots with multiple degrees of freedom that can move freely around space platforms to automatically build satellites and other mechanisms, establishing a satellite system that does not require launching from the ground. This will allow satellites nearing their lifetimes' end to be repaired/maintained/refueled in space instead of turning into space debris. Large structures can also be built in orbit. Furthermore, significant reductions in launching cost will help the space business grow.