

## Preparation of examination material for formulating the Moonshot target

Upon promoting the Moonshot Research and Development Program, in order to support the formulation of ambitious targets that the country should uphold, one man and one woman in average were nominated from each of one government office and eight ministries to form an examination team of 26 persons (including 16 men and 10 women). While they have policy background, they can study R&D concept or other ideas flexibly, not sticking to conventional way of thinking.

The materials for the formulation of Moonshot targets were prepared based on the handouts, presentations and members' comments at the 1st and 2nd Visionary Councils, as well as on the result from activity of "collecting proposals and ideas from the public". With the status and feasibility of existing research and development and the importance of social issues in mind, discussions were made on how appropriate targets for Moonshot should be, in line with the concept and criteria for formulating the targets presented in the Visionary Councils.



Scenes from the discussions in the examination team



# 01. Lead the second "Green Revolution" to contribute to solving global problem on food and environment

## Background

- ✓ Demand for food in the world is expected to reach 6.9 billion tons in 2050 (1.5 times that in 2000). On the other hand, unstable and imbalanced supply are inevitable due to abnormal weather and desertification caused by global warming.
- ✓ The world has been tackling the difficult issue of population growth with the "Green Revolution" promoted in the 1950s. At the same time, we are faced with challenges such as sustainability issues caused by heavy use of chemical fertilizers and adaptation to cultivation environment where climate change is in progress.
- ✓ If food production keeps increasing worldwide, resource prices will inevitably rise (the amount of resource of phosphate ore, for example, is 75 years). It will pose serious impact on Japan's agriculture, which relies heavily on foreign countries.

## Creating the future

- ✓ Establish a highly sustainable ultimate agricultural solution that does not rely on chemical fertilizers and pesticides, while adapting to cultivation environment which changes along the progress of global warming. Lead the second "Green Revolution" (sustainable increase in food production) by introducing the solutions into emerging countries in Asia, Africa and other regions.

### Inspiring

- ✓ Produce food in stable and sustainable manner even under unfavorable natural environments where desertification is in progress.
- ✓ With agricultural solution from Japan, its healthy food culture centered on rice and vegetables will spread across the world, expanding the global market for Japanese food (exports).

### Imaginative

- ✓ Biotechnology and other Japan's superior technologies contribute to solving global problem over food and environment.
- ✓ Contribute to sustainable increase in food production to improve presence of Japan.
- ✓ In search of cutting-edge research platforms, top researchers and companies from around the world will gather.

### Credible

- ✓ Develop the varieties of plants that require almost no chemical fertilizers.
- ✓ "Variety creation" technology in which optimal varieties (super crops) are grown by analysis by AI on genomic information; conversion of waste resources and nitrogen in the air into fertilizers, etc.

## Outline of proposals collected from the public

- ✓ Construct and materialize a paradigm of improvement and utilization of new crops built on advanced plant science based on genome science, data science, AI, etc. Realize the "Green Revolution 2.0" in the 21st century.
- ✓ Use cutting-edge technologies to develop new sustainable plant protection technologies that apply the functions of organisms; in particular, technologies to enable reduced use of pesticides.
- ✓ Achieve both stable food production and prevention of global warming by cultivating crops that can grow under climate changes.

## 02. Challenge to take control of zoonosis and other infections which are becoming more borderless

### Background

- ✓ The spread of cross-border livestock infections (**highly pathogenic avian influenza, hog cholera, etc.**) has been **developing into a global problem**.
- ✓ In addition, there are **threats to human beings of getting infections from livestock and wild animals** (emerging infectious diseases such as highly pathogenic avian influenza, SARS, MERS, and Ebola hemorrhagic fever).
- ✓ Today, with **global migration of humans and goods**, preparation and new challenges for zoonosis and other infections are urgent issues.

### Creating the future

- ✓ Ensure that **effective containment measures** are taken **in short period of time, including in developing countries**, such as **by predicting outbreaks of zoonosis and other infections** and preparing for provision of necessary vaccines.

### Inspiring

- ✓ **Contain** global spread of infection **at the source**.
- ✓ **Stabilization of livestock production**.
- ✓ **Significantly reduced risk of human infection** through livestock and wild animals.

### Imaginative

- ✓ Japan leads an **international network** for infectious disease control.
- ✓ The risk of infections in Japan is reduced dramatically.
- ✓ It is also applicable to researches on **infectious diseases for humans**.

### Credible

- ✓ Develop a system to supply **the world's first innovative insect-based vaccine** that can be used in developing countries as well.
- ✓ **Predict mutation of virus by AI**.
- ✓ Construction of a **global system to predict spread of infection**.

### Outline of proposals collected from the public

- ✓ Vaccine development technology essential for maintaining the life of a wide range of hosts, including humans, livestock (including farmed fish), wild animals, and companion animals.
- ✓ Development of technologies that can address infectious diseases that threaten humanity.
- ✓ Development and application of technologies on large-scale expression system for component vaccine by protein using recombinant technology.
- ✓ Establishment of a system to globally protect the pandemic in times of emergency, especially those which are caused by human infectious virulent virus.

### 03. A society where people can receive medical and nursing care suiting the individual's characteristics anytime and anywhere, without relying too much on medical staff and care givers

#### Background

- ✓ While the demand for medical and nursing care is expected to increase, with number of elderly people over 100 years old reaching 300,000 and proportion of single-person households reaching around 40% by 2040, it is estimated that **the decline in number of active workers who support medical care and nursing care will accelerate, particularly in rural areas.**
- ✓ **The demand for medical care and nursing care** is expected to **increase in many countries** in Europe, US, and Asia (by 2040, the average life span will be over 80 years in 59 countries around the world). It is necessary to establish and share the details on the world's first medical and nursing care system that does not rely much on human hands.

#### Creating the future

- ✓ Through the development of life support robots and infrastructure that enable medical treatment and nursery care at home, **establish a personal support system where elderly people can live independently without relying much on hands of other people.**
- ✓ By developing various tools for telemedicine and nursing care, create an environment where professionals can be freed from transportation and other unimportant task, to focus on core business.

#### Inspiring

- ✓ People can receive **necessary medical and nursing care services whenever and wherever they need it.**
- ✓ Medical staff and care givers can concentrate to work on humans (**"They can run their worksites with ease"** more than ever).

#### Imaginative

- ✓ **Resolve the shortage of** medical and nursing care **providers.**
- ✓ **Eliminate the regional disparities** in medical and nursing care.
- ✓ **Introduce** high quality medical and nursing care services **into other countries.**

#### Credible

- ✓ Professional education with **XR digital phantom.**
- ✓ **Human support robot.**
- ✓ Mobile biometric scanners and **telemedicine systems**, etc.

#### Outline of proposals collected from the public

- ✓ Analysis of brain big data in scale of hundreds of thousands, which uses brain, AI, and robot technologies.
- ✓ Mobility to provide a comfortable life without driving a car.
- ✓ Fully automated platform capable of autonomous operation in medical institutions and marine or space environments, and autonomous transportation to and operation in remote areas.

## 04. A society free of metabolic syndrome and even of life-style related diseases through enjoyable health investment

### Background

- ✓ The structure of diseases is changing in Japan and other countries. While the response to lifestyle-related diseases is becoming important, the importance of prevention thereof and of improving health condition by individuals is also increasing.
- ✓ On other hand, technologies to make them possible have been developing rapidly. For example, acquisition of various types of ecological data has been enabled by IoT devices and other technologies.
- ✓ The problem of obesity is becoming more serious in overseas; the market size of the healthcare industry for preventing obesity and lifestyle-related diseases is expected to reach 525 trillion yen (in 2030) worldwide.

### Creating the future

- ✓ Provide optimal prescriptions for lifestyle improvement that matches health risk of the individuals, and encourage them to change their behavior, so as to establish a system which enables them to maintain appropriate lifestyle habits.
- ✓ Create the world's first health and disease prevention service to drive global healthcare market.

### Inspiring

- ✓ Decline in the rate of metabolic syndrome and lifestyle-related diseases.
- ✓ Extension of healthy life.
- ✓ Provide healthy and enjoyable life from Japan to the world.

### Imaginative

- ✓ People can choose and maintain joyfully their perfect health lifestyles based on individuals' genetic information and physical constitution, etc.
- ✓ Avoid health risks such as metabolic syndrome and lifestyle-related diseases, and extend the healthy life span.

### Credible

- ✓ System to determine psychological condition from their voices.
- ✓ Advance disease detection by AI.
- ✓ Smartwares.
- ✓ Robot for locomotive syndrome (Smart Concierge).
- ✓ Maintenance of standard bio data.
- ... and others.

### Outline of proposals collected from the public

- ✓ Development of dietary supplements which prevents the world's three major diseases (dementia, diabetes, and cancer).
- ✓ AI dietary education doctor.
- ✓ Creation of multi-layered molecular map of whole human body.

## 05. Elucidate brain functions and make strong brains

### Background

- ✓ The total number of patients suffering mental illness exceeds 3 million. In recent years, mood disorders such as depression are becoming their major cause. Also, it is estimated that one in five elderly persons will suffer from dementia in 2025, which may become a serious social problem in the future.
- ✓ While Europe and US are competing in activities such as elucidating brain functions, we in Japan have accumulated a wealth of knowledge in the field of brain science.

### Creating the future

- ✓ Learn the mechanisms of such as dementia and depression by elucidating brain functions, and aim to establish the methods to prevent them.
- ✓ By understanding the human brain, the development of an artificial brain can also be expected.

### Inspiring

- ✓ Overcoming dementia and depression, etc.
- ✓ Declining number of developmental disabilities, etc.

### Imaginative

- ✓ Declined number of suicides.
- ✓ Rehabilitation into society of those who refusing the schools and hikikomoris (shut-ins).
- ✓ Extending healthy life.
- ✓ Developing artificial brain.

### Credible

- ✓ Development of technology that can easily visualize the activities of brain for the long term.
- ✓ Elucidating the mechanism in which a healthy turning into a disease.
- ✓ Elucidating the whole network of brain functions.

### Outline of proposals collected from the public

- ✓ An evaluation method that can directly measure mental disorders such as mental illness and depression.
- ✓ Because brain neurons are not regenerated in principle, replace them with artificial neural networks to support their functions.
- ✓ Conduct research for avoiding depression and dementia using technology that can capture the response from cranial nerve circuit including hippocampus.
- ✓ Prevention of dementia with dietary (How to raise health age without relying on medicine).

## 06. Ensure freedom of mobility to anyone anywhere

### Background

- ✓ **Aging and depopulation are accelerating rapidly** (in addition to the issue of aging, population in depopulating regions are declining at twice the pace of the national average). It is making them **difficult to maintain public transport infrastructure in the regions**.
- ✓ **Painful deaths** caused by elderly drivers **are a serious social problem**. When private car is the only means of transportation, returning the license will constrain the freedom of mobility.
- ✓ On the other hand, the EC market has been expanding. **The need for courier services has been increasing** (12% increase over 5 years: up 530 million packages), and there is a shortage of truck drivers.

### Creating the future

- ✓ With AI, edge computing, sensing, advanced automatic driving and traffic control using 5G, 3 dimensional traffic by drones, establishment of mobility services, and sharing of high value-added data with these systems, **secure the freedom of mobility and create a concept of community development and life support** to support the local community and the aging society, aiming for **zero fatal accidents caused by operational errors**.
- ✓ In some cases, human movement becomes unnecessary in the first place through advancement of technologies such as xR (generic term for such as virtual reality, augmented reality, mixed reality, etc.) and drones.

### Inspiring

- ✓ To a society where **even elderly people and non-license holders can freely move** (including virtually).
- ✓ **Overturn the concept of "mobility"** since the 20th century, which has focused on motorization.
- ✓ **Eliminate the painful traffic accidents** that are becoming a social issue.

### Imaginative

- ✓ Not only vehicles (devices), but also the **social systems change dramatically**, like logistics, lifestyles, transportation systems, etc.
- ✓ Accelerate the use of EC and autonomous driving and drones to **achieve zero shopping refugees**.
- ✓ By implementing sophisticated control, achieve **zero fatal accidents** caused by operation errors.

### Credible

- ✓ Development races intensify in each country for next-generation mobility technologies centered on autonomous driving.
- ✓ **Realize a new mobility frontier ahead of other countries** by backcasting from the ultimate mobility society, instead of next-generation vehicles.

### Outline of proposals collected from the public

- ✓ Assure the quality of fully autonomous driving by modeling the control flow and data flow.
- ✓ Realize a universal village that integrates IoT, autonomous driving, and use of renewable energy in sparsely populated areas such as remote islands, to optimize mobility and distribution in aging society.
- ✓ Development of dynamic map to control dynamic information of moving bodies.
- ✓ Zero interpersonal accident with "AI control".
- ✓ Development of a cooperative swarm intelligence agent in which many robots and small-scale sensors and actuators work together as a group.
- ✓ Development of "explanation-capable AI" which fundamentally understands the operation principle of machine learning.

## 07. See through under the ground to enter the age of underground space development

### Background

- ✓ While three-dimensional measurement technology on the ground by mobile mapping system (MMS) has been developed, **technology to visualize the space under the ground is not fully developed.**
- ✓ Technologies for visualizing underground are essential also to promote advanced use of underground and to **implement effectively the measures against disaster vulnerability and aging.**
- ✓ It is difficult to predict the occurrence of natural disasters and to estimate the damage in advance, **as the state of faults, geology and crust** that are the cause of frequent inland earthquakes **have not been fully understood.**

### Creating the future

- ✓ Trigger the business of advanced use of underground space which utilizes advanced ground information. **The age of underground space development will begin.**
- ✓ It makes vulnerabilities in infrastructure to be discovered and addressed smoothly, **enabling rapid recovery and prepared recovery.**
- ✓ **Elucidate fluctuation in faults** by monitoring the faults.

### Inspiring

- ✓ With the visualization of underground space, **the age of "underground city" development begins.**
- ✓ **Implement advanced maintenance of buried infrastructure.**
- ✓ Lead to elucidation of the mechanism of frequent **inland earthquakes.**

### Imaginative

- ✓ Realize three-dimensional measurement technology of the same level as on the ground, also in under the ground.
- ✓ If the condition of the fault in the ground can be observed, **monitoring of the fault will also be possible.**

### Credible

- ✓ Technical development of underground exploration technology using **underground radar, surface waves, electrical resistance, etc.** will start.
- ✓ In the future, the technology to see through underground will be developed with rapid development of analytical signal processing technology using underground radar and the like.

### Outline of proposals collected from the public

- ✓ In order to make effective use of deep underground space, elucidate the ground and rock properties, including groundwater, completely from the surface to the deep underground area.
- ✓ Reduce the construction period and cost in civil engineering work by detecting the structures buried underground, using electromagnetic wave radar.
- ✓ In addition to concrete, PC steel rods and steel members, visualize the interior condition under the ground completely.
- ✓ Land surface data assimilation, reanalysis, information fusion, and simulation earth science.
- ✓ Create a sustainable recycling-type living area in underground cavity on the moon by 2050.
- ✓ Realize a society free of resource depletion and natural disaster, by exploration into crustal structure.
- ✓ Direct exploration of interior and use of underground space of terrestrial planets and satellites by large-scale ultra deep excavations.

## 08. A new city that overcomes huge disasters and climate change

### Background

- ✓ With huge earthquakes, floods and landslides becoming frequent and intensifying worldwide, construction of cities that overcome climate change and natural disasters is urgent matter.
- ✓ In particular, coastal cities around the world have the risk of rising sea level and sinking ground due to global warming. The Indonesian government has recently decided to relocate its capital from Jakarta because of the sinking grounds.

### Creating the future

- ✓ Emergence of a completely new city of zero disaster damage that does not rely on the legacies such as aggregation or network of cities.
- ✓ Climate control in the city turns it into a comfortable and easy-to-live city all year round.
- ✓ Shelter cities and floating cities are expected to play a role as new bases for energy, water resources and disaster prevention. They also lead to the prospects for lunar base construction in the future.

### Inspiring

- ✓ Build zero disaster damage cities where no one senses the risk of disasters.
- ✓ Materialize a comfortable environment city by Micro Climate control.
- ✓ Realize a sustainable human society that can run under any environment.

### Imaginative

- ✓ Construct a disaster prevention environment city through data-driven city planning, material development, use of robotics, etc.
- ✓ Changes in human beings' living environment that overturn conventional common sense, such as over the ocean, under the sea, and the space.

### Credible

- ✓ The efforts of industry, government and academia have started worldwide for construction of floating city that overcomes the disasters and co-exists with the environment.
- ✓ It is necessary to deepen the solutions to environmental problems at the urban construction stages, such as green infrastructure.
- ✓ Ground floating research to completely shut off the tremor of a huge earthquake.

### Outline of proposals collected from the public

- ✓ Creation of innovative infrastructure that achieves zero disaster risk, zero environmental impact, and zero degradation.
- ✓ Data-driven super city planning for recovery from super huge disaster and for construction of polar city.
- ✓ Development of technology on the constructions in the space and examination for its use on the ground.
- ✓ Construction of digital twin simulator for designing the country's land in the 22nd century.
- ✓ Futuristic design that overcomes the five challenges facing the capital city Tokyo (environment and energy, food supply, urban disaster prevention, urban infrastructure, and defense system).
- ✓ Research on "hyper circular sphere pilot city" that ties virtual planning model and smart observation through social implementation.
- ✓ Complete protection of urban residents using high-resolution hazard detection and automatic control of meteorological disasters and flood damage.

## 09. Eliminate damage from wild birds and animals with the ultimate fully autonomous robot, etc.

### Background

- ✓ Declining population and economic activities in farming and fishing regions cause imbalances in the ecosystem, causing **serious damage by wild birds and animals** mainly in farming and mountain areas (Agricultural damage amounted to about 20 billion yen and damages in forested area of about 6,000 hectares).
- ✓ There are incidents of **wild birds and animals colliding with cars and trains** (approximately 47,000 roadkills on express ways). This has a significant effect on the daily lives of local residents.
- ✓ There are **impact on other wildlife** as well. Coexistence with wild birds and animals is also important from the perspective of **conservation of the environment such as biodiversity, forests and oceans** ((6) in the eight fields of SDGs implementation guidelines).

### Creating the future

- ✓ By developing and introducing fully autonomous robots, etc., managing village forests and farmland, controlling the density of birds and animals, and scaring them off, etc., **coexist with wild birds and animals to protect the environment of rich forests and farming and fishing villages**, and create **a region where residents can live with peace of mind**, such as eliminating the collisions with automobiles etc.

### Inspiring

- ✓ **Living protection in farming and fishing villages** where population is declining and aging.
- ✓ Favorable environment with the **coexistence of wild birds and animals and humans**.

### Imaginative

- ✓ **Balanced land development** by people settling in farming and fishing village area.
- ✓ **Gathering knowledge from around the world** for research on coexistence with wildlife.

### Credible

- ✓ **Fully autonomous robots** and drones that operate even under extreme conditions without external power and without radio waves reaching it.
- ✓ Technology to **prevent population increase** in **selected** wild birds and animals.
- ✓ **Technology to restore species that went extinct** due to damage from birds and animals.

### Outline of proposals collected from the public

- ✓ Construct a system to survey and control wild birds and animals utilizing technologies like IoT and 5G.
- ✓ Build human space which does not allow invasion of wild birds and animals or pests by fighting them off individually by AI and robot technology.
- ✓ Establish a technology to keep birds and animals such as wild boars and deer in the mountains.

## 10. Challenge for the world's most advanced new frontier of renewable energy, aiming for a society of net zero CO<sub>2</sub> emission

### Background

- ✓ While **fossil resources** such as coal and oil **are the main energy sources to support modern civilization**, **CO<sub>2</sub> has been emitted in large amounts** by their consumption in power generation, transportation, and production of core materials (iron, cement, etc.).
- ✓ As rising sea levels, large typhoons, unexpected sudden heavy rains, droughts and other abnormal weathers are occurring frequently, **concerns** are expanding **around the world on climate change**.
- ✓ **Japan's leadership** as a pioneer, particularly in new technologies, **is expected to achieve the so-called 2 °C goal and 1.5 °C challenge based on the Paris Agreement**.

### Creating the future

- ✓ By **developing a new renewable energy that has not yet been developed** and materializing a robust and flexible energy storage and supply system to accept the energy, **construct a new energy civilization society which possesses 3E&S** (even supply, economic efficiency, environmental protection, and safety) **simultaneously**. At the same time, promote decarbonization in the production, use, and recycling of materials, etc., and aim for a new manufacturing civilization society.
- ✓ Aim to **achieve net zero CO<sub>2</sub> emissions as early as possible in the second half of this century**.

### Inspiring

- ✓ Contribute significantly to **solving issues in climate change**.
- ✓ Solar and wind powers are under drastic cost reductions and penetration, but constant efforts are needed to find renewable energy that has not yet been developed.

### Imaginative

- ✓ **Decarbonize the sectors that generate large amounts of CO<sub>2</sub>**, such as power generation, transportation, and material production.
- ✓ Development of various renewable energy have been tried. Gather wisdom from all over the world by **challenging the untouched frontier**.

### Credible

- ✓ It is said that **if all the solar energy** reaching the earth **is converted**, the **world's annual energy consumption** can be provided **in about one hour**.
- ✓ It is required to use up yet to be used **wavelength of solar, ocean current, wind power, geothermal, etc.**

### Outline of proposals collected from the public

- ✓ Extraction of unused renewable energy utilizing the vast oceans (off land solar and wind power generations, ocean current power generation, hydrogen production, etc.)
- ✓ Development of innovative manufacturing technology that enables conversion from current manufacturing technology that emits large amount of CO<sub>2</sub> in the material industry.
- ✓ Production of useful substances using renewable energy (hydrogen, liquid fuel, ammonia, etc.).
- ✓ Development of innovative energy storage technology that stores renewable energy at very low cost such as heat storage.

## 11. Absorption and utilization of CO<sub>2</sub> for net zero CO<sub>2</sub> emission society

### Background

- ✓ In order to **achieve the so-called 2 °C goal and 1.5 °C challenge based on the Paris Agreement**, it is necessary not only to reduce CO<sub>2</sub> emissions, but also to **immobilize** and use **CO<sub>2</sub> that** has already been emitted or **will be emitted in the future**.
- ✓ Although CCS (CO<sub>2</sub> capture and storage) in which CO<sub>2</sub> is stored underground or other locations is gathering expectation, it has some problems such as economics, and has not been experiencing explosive expansion yet.

### Creating the future

- ✓ Develop super plants and microorganisms, which immobilize CO<sub>2</sub> at high speed and in large quantities, and DAC (capturing directly from the atmosphere), etc. Utilize the generated biomass as structural materials and industrial raw materials. For immobilization, use solar or other renewable energy, not energy derived from fossil resources.
- ✓ Aim to **achieve net zero CO<sub>2</sub> emissions as early as possible in the second half of this century**.

### Inspiring

- ✓ It is difficult to stop the temperature from rising just by suppressing the emission of CO<sub>2</sub>.
- ✓ Human wisdom is required to **absorb the large amounts of CO<sub>2</sub> which has been emitted since the industrial revolution and to make effective use of it**.

### Imaginative

- ✓ Challenge to **develop super plants and microorganisms** that dramatically enhance CO<sub>2</sub> absorption and to **reduce the cost of DAC**.
- ✓ Enable effective use of biomass and CO<sub>2</sub> from perspective of economy, and **decarbonize manufacturing of materials and fuels, transportation, etc.** which are based on fossil resources.

### Credible

- ✓ Although CCS technologies are available, it is necessary for the captured CO<sub>2</sub> to produce added value in order to be economically viable.
- ✓ **Japan leads the world in emerging technologies such as plant growth promotion technology and catalyst technology required for DAC**.

### Outline of proposals collected from the public

- ✓ Promote the growth of plants and microorganisms to dramatically increase the ability to immobilize CO<sub>2</sub> and capability to produce useful ingredients.
- ✓ Develop super resistant plants that can grow in harsh environments such as deserts and seawater.
- ✓ Develop CO<sub>2</sub> collection technology such as next-generation DAC that separates and collects lean CO<sub>2</sub> in atmosphere and seawater with low energy input and cost by using separation membrane, etc.
- ✓ Manufacture chemicals, concrete products, fuels, etc. at low energy input and low cost from CO<sub>2</sub> which is the main cause of global warming and is chemically stable.
- ✓ Manufacture carbon neutral or low carbon fuels and chemicals based on C1 chemistry.

## 12. Eliminate marine plastic waste to recover the beautiful ocean

### Background

- ✓ Worldwide, about 8 million tons of plastic waste are flowing out to the ocean annually, and it is said to exceed the amount of fish in 2050 if the current situation continues.
- ✓ The global loss, including the impact on the marine environment, obstacles to ship navigation, and the impact on tourism and fishing, is estimated to be approximately 13 billion dollars annually (approximately 1.4 trillion yen). Even from international viewpoint, it is an urgent issue.
- ✓ The global market for biodegradable plastics in 2030 is estimated to be about 500 billion yen.

### Creating the future

- ✓ By wider use of plastic that biodegrades promptly even if it spills out to the ocean, the establishment of technologies to recover and recycle marine plastic waste into resources, etc., eliminate the marine pollution caused by plastic waste, and restore the beautiful ocean.

### Inspiring

- ✓ Marine plastic waste is now a global issue. Competition for securing related markets is intensifying.
- ✓ For Japan, a maritime nation, it is an important theme that should be tackled by bringing together leading-edge wisdom in collaboration of industry, academia, and government.

### Imaginative

- ✓ Promote across the globe the plastic which is durable while in daily use and decomposes quickly when it flows out into the ocean.
- ✓ Recover the plastic waste automatically that has flowed into the ocean to eliminate marine plastic waste.

### Credible

- ✓ Japan leads the world in the research on bioplastics that decomposes in response to the surrounding environment (temperature, humidity, salt content, etc.).
- ✓ While US and China are ahead of us in AI technology, the key to the automatic recovery is the maintenance of real data such as ocean currents.

### Outline of proposals collected from the public

- ✓ Contribution to the development of marine biodegradable plastic that does not degrade under normal use conditions but decomposes under specific conditions, and to the solutions to issues of micro plastic.
- ✓ Development of a plastic that has a structure for easy decomposition in the ocean and is both biodegradable and stable.
- ✓ Development of bioplastics manufactured from agricultural waste and wood.
- ✓ Promote bioplastics and contribute to solve the issues of oil depletion and global warming.
- ✓ Development of multifunctional underwater drones and satellites that can detect and recover waste and investigate basic parameters (water temperature, salt contents, etc.) in the ocean.

## 13. Turning harmful substances in air, water and soil into useful resources

### Background

- ✓ Together with CO<sub>2</sub> causing climate change, **nitrogen compounds and phosphorus compounds, etc.**, contained in large amounts in exhaust gas and drained water from factories etc. all over the world **have already exceeded the limit of the natural circulation of the earth**. While these substances cause pollution, they are **essential to mankind as raw materials for fertilizers, etc.**
- ✓ We fall into a dilemma that if a large amount of energy is consumed to isolate and remove these harmful substances, CO<sub>2</sub> emissions will increase.

### Creating the future

- ✓ **Construct and materialize advanced resource recycling which isolates harmful substances contained in exhaust gas and drained water from factories, etc. and also those in the environment (air, water etc.), and make them into resources.**
- ✓ Aim for negative emissions (reduce total emissions of nitrogen compounds, phosphorus compounds, and CO<sub>2</sub>) to avoid energy consumption in these activities to increase CO<sub>2</sub> emissions, by a recycling-type production system designed from entire perspective, like utilizing energy from renewable energy with large supply fluctuations at the time it is being surplus.

### Inspiring

- ✓ **Evolving Japan's proud pollution control technology into material recycling technology, and contribute to the world facing food shortages.**
- ✓ Emissions of nitrogen compounds and phosphorus compounds to the atmosphere, ocean, and groundwater, etc. have already exceeded the capacity of natural circulation (planetary boundary).

### Imaginative

- ✓ Recycle from exhaust gas and drained water the raw materials for fertilizer which is essential to food production.
- ✓ **At the same time, eliminate the concerns over the large energy input at the time of ammonia production, and the lack of natural resources of phosphorus.**

### Credible

- ✓ There is an estimate that **if all the world's NO<sub>x</sub> emissions can be converted to ammonia, it accounts for around 40% of world demand.**
- ✓ Technology has been established if it is only the process of isolating harmful substances that matters. **Aim for negative emissions** including energy input.

### Outline of proposals collected from the public

- ✓ In order to reduce the release of artificially immobilized nitrogen compounds into the atmosphere, soil, and hydrosphere, establish a method of recycling nitrogen compound and nitrate ion to realize nitrogen circulation.
- ✓ Realization of a "completely sustainable society" in which all substances are recovered and reused endlessly in circulation by converting harmful substances in the environment (CO<sub>2</sub> and NO<sub>x</sub> in exhaust gas, CH<sub>4</sub> emitted from livestock, etc.) into resources.
- ✓ Securing safe and reassuring resources of phosphorus.

## 14. Eliminate dangerous work with completely unmanned construction site

### Background

- ✓ Around 2050, 70% of the world's population live in cities, and in emerging countries etc., shortage of infrastructure will become serious issue. At the same time, the efforts on building smart cities which are equipped with intelligence urban functions will expand around the world.
- ✓ In Japan, the aging infrastructure will become a problem. While maintenance costs for the next 40 years are expected to reach 547 trillion yen, need for making construction sites more efficient is inevitable.
- ✓ On the other hand, the number of those who choose the occupation of skilled workers and engineers supporting the construction site is decreasing sharply. Comparing the fiscal years 2011 with 1992, the number of young recruits declined remarkably: about 60% down in high school graduates, and about 40% down in college graduates and graduate-school graduates.

### Creating the future

- ✓ Realization of a comfortable construction industry free from labor shortage and dangerous work.
- ✓ Japan's construction industry expands into overseas as well, with the establishment of completely unmanned construction technology ahead of the world.
- ✓ In the future, it will be applicable to extreme environments such as polar zones, ocean floor, and even the lunar surface, contributing to the advancement of humanity into space.

### Inspiring

- ✓ Measures for solving issue of aging infrastructure.
- ✓ Realize completely safe and super efficient construction site.
- ✓ With the realization of construction under extreme environments and material development, look into expansion into the space in future.

### Imaginative

- ✓ Shortage of those who work in construction industry is resolved, and construction in a comfortable environment is realized.
- ✓ Maintenance costs improve dramatically, and Japan will dominate the global infrastructure market.
- ✓ It is applicable to maintenance of infrastructure compatible with smart city and other new city constructions.

### Credible

- ✓ Development of collaborative construction technologies such as multiple construction machines, 3D printers, etc. based on 3D drawing information is in progress.
- ✓ Development of new concrete-based material technology compatible to automation is in progress.
- ✓ Development of robots and drones equipped with innovative sensors, actuators, and mobility.

### Outline of proposals collected from the public

- ✓ Fully automated maintenance of infrastructure.
- ✓ Fully automated inspection of infrastructure with drones, satellites and artificial intelligence.
- ✓ Automatic construction by robots like in Minecraft.
- ✓ More efficient rescue in disasters, construction, and civil engineering work, with giant humanoid robots.
- ✓ Self relying-construction of lunar city by community of robots realizing self-manufacturing and restoration.
- ✓ Development and maintenance of social infrastructure equipped with intelligence.
- ✓ Development of robot automatically repairing traffic infrastructure, using drone and 3D laser printer.

## 15. Improve functions of human to allow everyone to live comfortably and happily

### Background

- ✓ It is estimated that Japan's **working-age population will** continue to **decline**, and will be **down by about 40% by 2065**.
- ✓ On the other hand, rejuvenation of the elderly people is being observed. The image of the elderly people has changed significantly, such as their rising employment rates.
- ✓ Under these circumstances, it is important to **develop an environment that can respond to the desire to work regardless of any physical and mental conditions**, and to **aim to** increase the labor force and **improve labor productivity**.
- ✓ Furthermore, it is required to create conditions where people live without physical restrictions, with aim for living, and are allowed to participate in society.

### Creating the future

- ✓ By developing tools that can restore and improve cognitive and physical functions of human, **realize a society where everyone can work safely and comfortably according to the situation and desire of individuals** that change daily.

### Inspiring

- ✓ **Labor productivity is maintained and improved** even in a society with low birth rate and aging population.
- ✓ **People can live based on values of the individuals**, regardless of their physical and mental condition.

### Imaginative

- ✓ **Complement the reduced or lost functions with innovative technology**, making it possible for everyone to have an autonomous life and social participation more comfortably.
- ✓ **Add the abilities that everyone is not good at from the outside**, to expand the opportunities for success dramatically.

### Credible

- ✓ **AI that understands the meaning** and can communicate that to people.
- ✓ BMI (Brain Machine Interface) technology that enables declaration of intention and machine operation.
- ✓ **High-performance actuator** that complements and extends body functions.  
... and others.

### Outline of proposals collected from the public

- ✓ Development of technology to read out a large amount of information accurately from the brain non-invasively and connect with a computer.
- ✓ Based on the five senses of human, expand human capabilities by developing innovative sensing systems that capture the subject from the periphery to the center as a whole, and sensory complementation devices for people with sensory organ defects.
- ✓ Development of AI that can understand general common sense and expert knowledge to extend human knowledge and memory; research on BMI that enables people to access massive knowledge and memory at high speed; and understanding of emotional mental activities and implementation thereof to ICT.
- ✓ State-of-the-art technologies such as brain science, artificial intelligence, and robotics to maintain mental and physical health for all generations and to maximize potential ability of individuals.
- ✓ Development of super-sensing and actuating technology for extending healthy lifespan and for the realization of a society where people can work comfortably while they are healthy.

## 16. Creation of Post-Internet

### Background

- ✓ Currently, the Internet transmits all "digital information" as an "information superhighway". However, **new social issues are emerging that are caused by the Internet itself**, such as **the spread of fake news, the pressure to the logistics by Internet mail orders, and the fear of privacy infringement and information security.**
- ✓ A new platform is needed to support Society 5.0, which realizes **Data Free Flow with Trust.**

### Creating the future

- ✓ Providing **reliable information that each person needs, digitizing everything to make things at the nearest location** will **create new Internet** assured with adequate privacy and security.

### Inspiring

- ✓ **Necessary information is instantly extracted** from a huge amount of information.
- ✓ Transform the society **from division and competition to co-prosperity.**
- ✓ Establish **infrastructure appropriate to Society 5.0** based on the reality of the "information society".

### Imaginative

- ✓ **Eliminate** all social issues related to logistics (**overwork, traffic congestion, and high costs**).
- ✓ Realize an era where **"you can get anything on the net for sure."**

### Credible

- ✓ **Ultra-high-speed communication** technology that sends a movie to a terminal in an instant.
- ✓ Scanning and reproduction technology that **digitizes and actualizes things.**
- ✓ **AI which stays close to people.**
- ✓ Absolutely secure encryption.

### Outline of proposals collected from the public

- ✓ Capacity for Information and communication is expected to increase explosively. It is urgent to increase communication capacity.
- ✓ Computerization, digitization, and automation of living space are not progressing at all.
- ✓ New technology to realize protection of personal information and assurance of credibility in public environment.
- ✓ By taking out the necessary information from the vast amount of information and making appropriate use of it, exploit the abilities of all individuals and realize humanistic communication.
- ✓ In order to support the expansion of knowledge in the future society, establishment of a new methodology of distributing knowledge and rapid development of information infrastructure to realize this are essential.
- ✓ By being able to produce what people need when they need it with 3D printers etc. in every home, unnecessary consumption of various resources occurring in logistics and inventory can be eliminated.

## 17. Quantum CREATION

### -Recreation of the World with Quantum-

#### Background

- ✓ With recent technological advances, **quantum technologies** such as quantum computer, quantum measurement and sensing, quantum communication and cryptography, and quantum material, are expected **to surpass current common sense and revolutionize the future economy and society.**
- ✓ **US, Europe, and China have recognized the technology affect future national security and economic competitiveness.** They have positioned them as an important technology for their national strategy, and are rapidly developing efforts such as expansion of investment on the research and development.

#### Creating the future

- ✓ With quantum technology, **break through the limits of industry and society in all segments such as telecommunications, medical care and environmental energy,** which are dominated by existing technologies. Replace the existing technologies and create new values and worldviews. Aim to re-create existing markets and systems, such as **realization of super energy saving and high precision AI** by integration with AI, **small-sized precision medical diagnosis by integration with bio,** and **replacement of the existing Internet** by integration with ICT.

#### Inspiring

- ✓ **Renovate the information infrastructure with energy saving, large capacity, and highly sensitive quantum internet.**
- ✓ **High-speed drug efficacy determination** with real-time metabolic imaging.
- ✓ **Fundamental solution of energy issues** with super energy saving and energy generating devices.

#### Imaginative

- ✓ **Solve complex social problems instantly with quantum AI,** and provide optimal solutions.
- ✓ **Implement** advanced examinations that can only be done at a large hospital **easily with a health checkup.**
- ✓ **Elucidate fundamental principles of the universe. A new paradigm in physics.**

#### Credible

- ✓ **Small-scale quantum computer is realized.** Countries are developing fierce large-scale competition.
- ✓ Develop an **absolutely safe encryption** for every computer.
- ✓ Quantum sensor that exceeds conventional sensitivity and accuracy by orders of magnitude.

#### Outline of proposals collected from the public

- ✓ The base technology required to realize SOCIETY 5.0 is the realization of quantum computing operated at room temperature. The realization of quantum computing can bring all technologies such as AI, medical care, and autonomous driving to the next stage.
- ✓ The perfect physical security of the information network that utilizes quantum cryptography communication, quantum computer, etc. is the assignment for the humanity.
- ✓ Bold ideas such as ultra-large-capacity memory using spintronics that can address the increase of information communication are indispensable.
- ✓ Using Bio-mimic technology which applies quantum biology, materialize highly efficient artificial photosynthesis, solar power generation, cancer treatment, increased food production, medical gene editing in medicine, completely new sensing technology, and information society of the next-generation with all new sensing technology.

## 18. Race for the Mars "Mars shot" by small space probe

- Reaching Mars by 2023 and exploring for water, oxygen, etc. -

### Background

- ✓ The near-Earth space zone is **expected to be a new frontier for the growing space industry** (approximately 40 trillion yen in 2017, 20% year-on-year increase).
- ✓ The former Soviet Union and the United States reached Mars in the 1970s. **Large-scale scientific Mars exploration satellite projects** are currently underway **led by governments of the countries**.
- ✓ From now on, it is important to **accelerate the entry of start-up companies and the companies in non-space industry**.

### Creating the future

- ✓ With **the government supporting the brave challenges of the private sector to the innovative space technology, create new values and the space industry from Japan**, in the space economy zone that has not existed yet.
- ✓ **Understand the actual conditions of water, oxygen, etc. of Mars that are important for maintaining life**, which is the premise of the future migration to Mars.

### Inspiring

- ✓ With **the Japanese government preparing the means of launching**, realize the race that starts from space.
- ✓ **Start of the examination of the technical and institutional aspects necessary for sustainable Mars development** (allocation of communication electromagnetic waves, etc.).

### Imaginative

- ✓ **Improve technologies for manufacturing and controlling spacecraft at low-cost and high-frequency**, using a small-sized jointed spacecraft.
- ✓ Japan's "reliable and compact" technology drives the development of Mars.
- ✓ Securing **competitiveness** through new methods such as the **introduction of award methods**.

### Credible

- ✓ In 2014, Japan succeeded in **launching** the ultra-small deep space probe "PROCYON" **together with "Hayabusa2"**, **demonstrating the world's best technology**.
- ✓ The probe will reach Mars by 2023. It will measure water, oxygen, etc. by small electromagnetic waves sensor technology that Japan is good at.

### Outline of proposals collected from the public

- ✓ Expansion of human life and economic zone, residence in space, utilization and development of the moon (space colony, space environment city, lunar surface city, lunar underground city, plant factory in the space, space version of "local production for local consumption", and maintenance of life in closed space and safety measures)
- ✓ Development of innovative electric propulsion technology for spacecraft, development of airplanes on the Mars.
- ✓ Space weather forecast service for anywhere in the solar system.
- ✓ Exploration and development of the space by unmanned, energy saving, and automation technology.
- ✓ High-speed, large-capacity communication technology between planets, and real-time understanding of information from probes.
- ✓ Securing water, food, resources, energy, etc. in space (artificial photosynthesis, bio in the space, water regeneration and circulation, waste recycling, nutrition from excrement.)
- ✓ ELSI (research on ethics, law, and social issues) in using space.

## 19. Sustainable Use of Space "Space Version of 3R"

- Launching satellite fueling station and space loading service in 2030 -

### Background

- ✓ **Satellites, etc.** that are used for weather forecasting, communication and broadcasting, positioning and getting picture at disasters **are extremely important infrastructure.**
- ✓ Space debris are increasing exponentially. If it becomes difficult to use satellites in the future, not only it will have **adverse effect on industrial activities**, but also **will affect the comfortable daily life and ease of living.**
- ✓ Make space debris removal technology, which is Japan's strength, **not a government business but opportunities for private business.**
- ✓ For this purpose, develop **3R (Reduce, Reuse, and Repair) technologies on satellites, etc.** in space orbit. Attract private enterprises including spin-offs, **and lead them to commercialization.**

### Creating the future

- ✓ 3Rs (refueling, light repair, and repair of satellite) on satellites support development of space infrastructure that is indispensable for new entry of private enterprise and quick response to and mitigation of disasters. It realizes **sustainable use of space, improves industrial competitiveness, and promotes the utilization in daily lives.**
- ✓ In addition, for example, **autonomous control technology** (space version of automatic travel technology that brings together wisdom such as autonomous judgment, control and communication technology) produces **technical breakthrough** in AI, robotics, communication, etc., **and spin outs to industries other than space industry, contributing to a wide range of fields**, including disaster monitoring by satellites.

### Inspiring

- ✓ Present options other than rockets (also avoiding launch delays).
- ✓ **Change the games in space industry (Japan makes the rules).**
- ✓ The technologies like autonomous control of satellite also spread to the industries and **contributes to the disaster response, etc..**

### Imaginative

- ✓ **Establishment of sustainable space infrastructure** by autonomous control technology of small satellites.
- ✓ **Realization of dramatically longer life** of large satellites, etc.
- ✓ 3R is maintained as a **space business ecosystem.**

### Credible

- ✓ **By 2029, realize** technology of close encountering and docking, autonomous control, modularization and faster debris removal for satellites.
- ✓ In 2030, start private service on the space version of 3R platform.

### Outline of proposals collected from the public

- ✓ Assurance for stable and sustainable use of orbital resources, that is, improvement of space environment by reduction and removal of space debris, is a major social issue to be solved by the state-of-the-art technology.
- ✓ Space debris, if left unchecked, is expected to proliferate exponentially due to collisions. There is a concern that the value of use of satellite orbits, which are limited world assets, will be greatly reduced.
- ✓ Space version of road service is needed to prevent debris by inspection, repair and refueling of satellites, and to wreck the debris (removing them by letting them entering into the atmosphere).
- ✓ For the preservation of space environment, being aware of situation in the space (SSA) accompanying the emergence of mega constellation concept, reinforcement of space traffic control (STM), and collision prevention measures are urgent issues.

## 20. Make the most use of the benefits of the ocean to become "Food and Resource-Rich Japan"

### Background

- ✓ Japan has an **exclusive economic zone of 12 times the land area** (approximately 4.47 million km<sup>2</sup>, 6th in the world) and a continental shelf of approximately 650,000 km<sup>2</sup>. **The potential of the ocean is expected to be extremely large.**
- ✓ In recent years, it has been found that **mineral resources such as manganese and cobalt are widely distributed** in the seabed near Japan.
- ✓ In addition, while **demand for marine products is rising** and **fishery resources are decreasing worldwide**, it is important to implement Japan's advanced aquaculture technology, etc. and **lead** the world with recovering resources such as eel and bluefin tuna, and **sustainable use of fishery resources.**

### Creating the future

- ✓ **Maximize the potential of the ocean space**, increase dramatically the amount of resources to obtain, and aim for a **food and resource rich country.**

#### Inspiring

- ✓ Make the sea and seabed near Japan a **treasure trove filled with rare resources.**
- ✓ Bring eel and bluefin tuna with affordable price from the **ocean farm.**
- ✓ **Turn the ocean into large-scale farm.**

#### Imaginative

- ✓ **Lead the world with Japan's marine exploration technology.**
- ✓ Mass-produce fish at **marine ranch** on the ocean, and **restore the amount of resources dramatically.**
- ✓ **Revitalize the remote island economy** with aquaculture and marine agriculture.

#### Credible

- ✓ Japan's **world-class deep-sea exploration technology.**
- ✓ Develop a **giant fish pen** on the sea, more than several hundred meters in diameter.
- ✓ In Convention on Biological Diversity, etc., one of the goals is "Proliferation and sustainable aquaculture in consideration of biodiversity".

### Outline of proposals collected from the public

- ✓ In order to meet the future increase in fishery demand, establish a new aquaculture method for sustainable growth of fishery resources and for safely improving the aquaculture production volume.
- ✓ Development of marine robots that actively acquire new resources in a wide area of EEZ, etc.
- ✓ Increase the amount of fish by creating an artificial upwelling zone using renewable energy to keep the amount of plankton feed high.
- ✓ Temporarily and spatially comprehensive understanding and prediction of natural phenomena and human activities in ocean area around Japan, such as global warming and changes in distribution and amount of marine resources, using sensors that can operate independently.

## 21. Undersea and seabed GPS program

### Background

- ✓ With regard to understanding of the topography of the seabed, various effects are expected, such as ensuring the safety of navigation of ships and AUVs (autonomous unmanned underwater vehicles), predicting earthquakes and seafloor volcanoes, and resource exploration. **Japan leads the world in deep-sea ocean floor survey technology utilizing underwater unmanned probes, etc.** (At the end of last year, JAMSTEC and other teams from Japan advanced to the final competition of the international competition where they compete for ocean floor mapping technology.)
- ✓ On the other hand, because GPS satellite signals do not reach into the ocean and the attenuation of light and sound waves are significant underwater, it is **difficult to determine the position of the underwater probe with high accuracy, and to understand minute crustal movements**. It is necessary to develop technology taking advantage of Japan's technological superiority.

### Creating the future

- ✓ **Establish an international platform** that enables us to understand in detail the position information under the ocean and on ocean floor, and the condition of the crust at sea floor, etc. Make rapid progress in ocean development, earthquake disaster prevention, etc., to **lead new ocean business**.

#### Inspiring

- ✓ Enable detailed understanding of location information underwater and on the seabed, let it lead to a **breakthrough in ocean development**.

#### Imaginative

- ✓ Contribute to **the development of methane hydrate, seabed ore deposit, etc.** by detailed position determination in the sea and seabed.
- ✓ Realization of disaster prevention and mitigation by **grasping information on activities such as subduction-zone earthquakes and seafloor volcanoes**.

#### Credible

- ✓ **Light sensing** that enables immediate grasp of crustal movement.
- ✓ Development of an **autonomous AUV** equipped with a **quantum gyroscope** with only small errors.
- ✓ Development of underwater communication and positioning technology using sound, etc. and **maintenance of base in the ocean area**.

### Outline of proposals collected from the public

- ✓ There is a need for rapid development of sensing (optical fiber etc.) technology in the sea area, exploration and observation technology, underwater / seabed robot technology utilizing drones, etc., and civil engineering technology.
- ✓ Maintenance of multipurpose marine environment monitoring system for meteorological and marine data, earthquake disaster prevention, etc. for the purpose of preservation and protection of national interest.
- ✓ Marine exploration and acquisition of ocean data by autonomous control robot.
- ✓ Create a technique to make measurements under the sea spatiotemporally, like measuring the atmosphere with satellites.
- ✓ Development of underwater wireless power information transmission, autonomous unmanned underwater vehicle, and seafloor station.