

The Plan for Achieving Mid to Long-term
Objectives of National R&D Agency
Japan Agency for Marine-Earth Science and Technology
(Mid to Long-term Plan)
(Draft)

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Japan Agency for Marine-Earth Science and Technology
(JAMSTEC)

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Introduction

The National R&D Agency JAMSTEC (hereinafter referred to as the “Agency”), pursuant to the provisions of 5-1, Article 35 of the Act on General Rules for Incorporated Administrative Agency (Act No. 103 of 1999), has established a plan to achieve its mid to long-term objectives (hereinafter referred to as the “Mid to Long-term Plan”).

Preface

The Agency aims to enhance marine science and technology standards and make contribution to the development of academic research by conducting fundamental R&D on the oceans and cooperating for academic research on the oceans in a comprehensive manner based on the principles of peace and welfare.

In the 5th Science and Technology Basic Plan (decided by the Cabinet on January 22, 2016), marine science and technology is considered as part of science and technology which will produce great values critical for national strategy. In the 3rd Basic Plan on Ocean Policy (decided by the Cabinet on May 15, 2018), enhancement of scientific knowledge is always considered as one of the Agency’s major initiatives to be implemented, and therefore, efforts for ensuring full maritime security, including the establishment of a Maritime Domain Awareness (MDA) system, and provisions for promoting Japan’s Arctic Policy were newly added to its working agenda. Moreover, R&D is essential for achieving the goal of Society 5.0 even in the field of oceanographic science, for instance, by creating new values using the artificial intelligence (AI) and big data analysis that leads to economic development and creates solutions to social issues.

With regard to international situations, the control, conservation and sustainable use of the oceans and marine resources were included in the Sustainable Development Goals (SDGs) (UN Sustainable Development Summit in September 2015), in the G7 Ise-Shima Leaders’ Declaration (May 2016), in the communiqué of G7 Science and Technology Ministers’ Meeting in Tsukuba (May 2016), and in Decade of Ocean Science for Sustainable Development (2021-2030) (proclaimed at the 72nd UN General Assembly in December 2017). This indicates that the importance of the oceans has become a common understanding both in Japan and abroad. In addition, considering the importance of the Arctic Ocean in the international community, the first Arctic Science Ministerial Meeting was held in 2016. The third Meeting will be held in Japan in 2020.

The Agency will contribute to the creation of future of the Earth by human society by taking into consideration the changes in domestic and international situations and the accompanying issues as described above, and grasping the whole global environment centering on the ocean, that is, complex and various systems that constitute the earth including vital activities as the “ocean, ground, and life” in an integrated manner, promoting mutual influence with human activities that greatly exert influence on the

future of the earth, and providing scientific knowledge as useful information. Therefore, the Agency will promote the operation of various and advanced R&D on the entire earth from the ocean and research infrastructure such as research vessels and explorers, and computer systems etc. It will play a role as a core institution of Japan's marine science and technology by enhancing the abilities of integration and analysis of observation and forecast data, and promoting the creation and dissemination of high outcome levels.

The Agency will further expand its efforts to meet the expectations of the people by contributing to the realization of a maritime nation through the creation of innovation, enhancement of safety and security of Japan and scientific knowledge:

- Promote R&D for the enhancement of scientific knowledge, solve issues such as understanding of the existing conditions of global environmental changes and the influences by human actions, forecast the future changes, effective and sustainable utilization of the useful resources created in the ocean such as living creatures and minerals, and contribute to countermeasures against the disasters resulting from hazards such as earthquakes and volcanic activities in the oceans and tsunamis thus created.
- Create and distribute useful information through the integration and analysis of data obtained from diversified investigations and observations, etc.
- Promote challenging and original R&D toward the creation of knowledge that supports next-generation marine science and technology
- Promote the development of advanced basic technology such as the upgrading of oceanographic survey and observation technologies for acquisition of exploration and survey capabilities suitable for diversified marine environments such as icy sea area, deep sea floors and ocean sub-bottom areas

To solve these issues, with the strong awareness of maximizing the outcomes, the national research and development agency establishes the system of collaboration and cooperation with various research institutes, industry, ministries and agencies in Japan and abroad, and promotes R&D to lead international projects. Under the leadership of the Chief Director, the Agency will further reinforce its internal control and governance, and work to develop and secure diverse human resources.

I Measures for achieving the objectives of maximization of R&D achievements, and improvement of the quality of other operations

1. Promotion of fundamental R&D in marine science and technology

The agency promotes the following R&D in this period of mid to long-term objective, develops and organizes large research facilities such as marine survey platforms and computer systems to correspond to the four challenges described in the preamble:
-“Enhancement of scientific knowledge related to the preservation and sustainable use of

the global environment and countermeasures against disasters originating from sea areas,”
-“Integration and enhancement of analysis of large-scale data, and information distribution to the society,”

-“Creation of knowledge to support next-generation science and technology through promotion of the challenging and original R&D,” and

-“Developing an exploration and research system that enables access to diverse marine environments.

In addition, the Agency aims for maximizing its ability as a Japanese core institution related to the marine science and technology and one of world-leading marine-earth science and technology development facilities by always capturing, constantly reviewing and focusing on policy and social needs as well as working in collaboration and cooperation with diversified sectors of industry, university and government. Furthermore, taking advantage of strength of being an integrated research institution, the Agency will work not only on large-scale R&D but also on the enhancement of challenging and creative R&D with an eye on the future, and will seek international standardization such as automation, labor saving, downsizing, analysis, prediction method, etc.

The Agency arouses “interests in science and technology that develop frontiers of knowledge” for all generations of Japanese, especially young people, while through collaboration with education institutions such as high schools, colleges of technology, universities, and private companies engaged in marine, infrastructure, information industry, etc. the Agency will also contribute to human resource development to support Japan’s science and technology.

(1) R&D for situational awareness of global environmental and forecast of changes

In this issue, utilizing the international research framework and cooperation system, the Agency will promote R&D related to observations and predictions that contribute to the preservation of global environment. Therefore, the Agency will focus not only on the waters around Japan but also areas where it has replicated best results including the Arctic sea, the northwest Pacific, tropical Pacific and Indian Ocean. It will scientifically analyze the globally challenging issues, such as, the conditions of environmental changes such as ocean acidification, hypoxic sea water, temperature rise, loss of biological diversity, and influences of pollutants over a wide area, from the surface to deep layers and from several years to 100 years of these changes and will work on mid to long-term forecasts. The priority areas mentioned above also have influences in determining Japan’s seasonal climates. The Agency will seek better understanding of processes of various phenomena that occur, promote automation of observation instruments and methods and downsize the instruments aiming at unmanned labor-saving observation that will promote an efficient observation network.

The Agency will send the scientific data and knowledge obtained in this project through various types of activities to the Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC), the Intergovernmental Oceanographic Commission (IOC), the Intergovernmental Panel on Climate Change (IPCC), working groups of the Arctic Council (AC).the international political tasks such as SDGs especially Goal 13 (specific measures against climate changes) and Goal 14 (protect the ocean's richness). This will contribute to the achievement of international policy issues as shown in the Japanese Basic Plan on Ocean Policy.

[1] Understanding of changes of marine environment through observation and development of observation technologies

This issue enables the Agency to accurately grasp the changes in physical and chemical of the ocean environment and contribute to accelerate the scientific cycles of observation, theory, and prediction. Especially, the Agency will estimate heat balance, fresh water balance, and material balance in the northwest and tropical Pacific, deepens the understanding of their consistency in mutual activities between them and air-sea interactions, and will observe and study the physical and chemical changes of marine environments all over the planet for further understanding.

Specifically, by FY2021, the Agency will work on:

- Development of new observation technologies by maintenance and application of the observation systems implemented under the international framework, practical application of the surface layer glider and unmanned autonomous navigator to save operations of the large mooring buoy, floating observation float to enhance automatic observation.
- Experimental observation using the above-mentioned new technologies in seas including the tropics, where the air-sea interaction is active, in order to understand the elementary reactions of phenomena in seas and air.

Furthermore, based on these progresses, by FY2025 the Agency will work on:

- Reconstruction of the structure of subarctic ocean and the maintenance mechanism by examining the actual conditions of heat balance, fresh water balance, and material balance between ocean and atmosphere at the ocean basin level in the northwest Pacific using an observation system that integrates existing and new technologies.
- Grasp the phenomenal generation process such as El Niño and dipole modes in the Indian Ocean, which exert great influence over Japan's seasonal climates and their relationships with ocean circulation in the tropical Pacific region, the behavior of water mass, transport process, etc.

In addition, the Agency will verify the effectiveness of new observation system, propose the direction of the next-generation Global Ocean Observation System to the world while

obtaining supports from island countries and will aim to establish the observation data distribution network to constantly understand changes in the ocean and atmosphere in the tropics.

[2] Understanding of environmental changes in the Arctic sea and development of monitoring technologies under-the-sea ice

The Agency will conduct R&D by promoting data acquisition to understand the current status of marine and sea ice environments in the Arctic sea, where the influences of the global warming are most prominent, to reduce the uncertainty in future predictions on the environmental changes in the Arctic sea, and to deepen understanding of the climate and environment systems such as interactions between the ocean and sea ice.

Specifically, by FY2021, the Agency will:

- Analyze and visualize spatio-temporal changes on environmental elements such as basic production in the Arctic ocean by using observation data and observation satellite data from the ships, mooring system, drifting buoy, etc., and publish the data
- Participate in the Arctic ocean wide-area observation plan, obtain highly accurate data, and publish the data
- Create knowledge on relationship between changes in the ocean and sea ice environment and climate changes by comparing and analyzing the existing data and newly obtained data, developing and using climate models, etc.
- Develop elemental technology concerning small-scale under-sea-ice observation drone for the enhancement of the Arctic Ocean observation, produce drone pilot units, implement operational evaluation by an actual sea trial, and promote examinations for construction of Arctic region research vessels.

Furthermore, based on these progresses, by FY2025 the Agency will work on:

- Provide the obtained data and knowledge to an environment assessment report created and published by a working group of the Arctic Council (AC)
- Implement the Arctic ocean wide-area observation on a continuous basis and publish the data for data expansion comparable to the middle latitude zone and tropics
- Provide knowledge that contributes to reduce uncertainty in the future prediction based on physical understanding of the ocean and sea ice in the Arctic region through the integration of observation data and numerical experimental results
- Operate a new Arctic ocean observation system by using an under-sea-ice observation drone.

[3] Understanding the interactions between the earth's surface and human activities

The Agency will conduct research to understand water and material circulations, ecological changes, etc., in oceans, atmosphere, and lands which are inseparable from

each other to comprehensively treat the earth's surface, in two approaches of observation and prediction, and will also conduct R&D to understand the interactions between these changes of the earth's surface and human activities to focus on regions that influence global climates and environments including the coastal areas of Japan where economic activities are active, and the Arctic area where the influence of the global warming is quite notable.

Specifically, by FY2021, the Agency will:

- Propose new observation systems using biogeochemistry observation float, autonomous underwater glider, air craft, etc., and enhance the atmospheric and marine observation by vessels, mooring system buoy
- Grasp the existing conditions of the cycles of carbons and trace substance, marine ecology, changes of terrestrial vegetation through the reduction of blind spots of marine environmental actual values concerning the ocean acidification, temperature rise, hypoxic sea water, etc., and data enhancement
- Conduct comprehensive analysis of numeric experimental results, etc. through atmospheric, marine and other observation data, observation satellite data, and prediction model to develop the understanding of water balance, material balance, energy balance, etc. per process in previously described phenomena
- Evaluate interactions between human activities and the environmental pollutions in the Arctic area, where the environmental pollutions such as black carbon deposition and ocean acidification are developing, and in Asia-Pacific region, a main generation source of causative agents.
- Grasp and predict changes in oceanic conditions and transmit information in a coordinated manner with (4), using the area surrounding the Tsugaru Straits, a coastal area where the Agency has accumulated knowledge as a test sea area.

Furthermore, based on these progresses, by FY2025 the Agency will work on:

- Create knowledge by comprehensively linking human activities and environmental changes such as environmental pollutions and functional changes of marine ecology caused by the pollutions by integrating various types of observation data, numeric examination results, etc., and developing quantitative understanding of responses from the marine ecology and material cycles against diversified environmental stressors
- Achieve consistent understanding of the material cycles, ecosystem changes, and physicochemical phenomena in ocean-atmosphere-land, and clarify interactions between earth's surface and human activities based on the understanding, and the relation between them and climate changes.

[4] Forecast of fluctuation of global environment

Until now, the global environmental change models have focused on a space-time scale of each of the various sub-systems that make up the Earth system, and several such models have been developed relatively independently. In this mid to long-term objective period, the Agency will improve the individual reproducibility and prediction accuracy by strengthening collaboration between these global environmental change models and the observation researches, and promote coordination among models by using good points including high reproducibility in a space-time scale a model excels at. These provide new knowledge on extreme phenomena and environmental change mechanisms generated by interactions of spheres such as duplicated regions of space-time scales, the atmosphere, hydrosphere, biosphere, etc., handled by models. The Agency aims at driving the collaboration system among several institutions as a core concerning the study on prediction of Japanese global environmental change through these activities.

Specifically, by FY2021, the Agency will:

- Improve the accuracy of numerical calculation to deepen the understanding of the influence of Madden-Julian Oscillation (MJO) over typhoons that fluctuates over a shorter time scale on the time scale of few weeks to seasonal variations on typhoons, etc.
- Further develop a numerical calculation system that can handle environmental changes over a few weeks to around a decade by linking these models with each other, and further improving the accuracy of individual models developed so far by applying to various phenomena such as changes of greenhouse-gas concentration, ocean acidification, hypoxic sea water, and changes of clouds, etc.
- Sophisticate modeling methods based on the understanding of oceans and elementary reactions of atmosphere, the material circulation among individual elements by using the method, develop new methods for interactions of the physical and chemical phenomena.

Furthermore, based on these progresses, by FY2025 the Agency will work on:

- Develop probability prediction methods for extreme phenomena in a typhoon, etc., get understanding of large-scale change phenomena in a time scale from several weeks to a season, understand the interaction mechanism, and create knowledge on prediction of these phenomena.
- Conduct a comparative verification between the predicted results and observation data by using a higher-precision numerical measurement system and a climate change factor analysis including interactions with human activities under consideration of providing knowledge
- Work on provision of knowledge that contributes to planning of measures to suppress the global warming and countermeasures.

[5] Impact assessment of global environmental change and human activities on biodiversity

In addition to grasping the changes in marine biodiversity, one of the most important indications of the global environmental change, the Agency will acquire knowledge that contributes to the evaluation of impacts of human activities on the ecosystems. In particular, the Agency will conduct investigations such as environment DNA analysis and in - situ monitoring and analysis integrated with environment data for amplification of the scientific knowledge of deep-sea ecosystems. A little information has been acquired so far on impacts on deep-sea ecosystems from marine environmental changes.

Furthermore, in order to gain insights into the actual conditions of human impacts on deep-sea ecosystems and diversity, the Agency will work on the optimization of environmental impact assessment methods as well as development of new measurement technique for marine plastic wastes and data expansion.

Specifically, by FY2021, the Agency will:

- Grasp the current status of biodistribution and diversity in deep-sea areas by conducting environment DNA analysis, in - situ monitoring, etc.
- Conduct distribution survey concerning marine plastic wastes and develop new measurement technique to efficiently understand types, shapes, and number of marine plastic wastes
- Optimize the environmental impact assessment methods and tool development for it
- Strengthen existing international collaboration to solve social challenges by providing data to databases positioned as an international framework and providing scientific knowledge.

Furthermore, based on these progresses, by FY2025 the Agency will:

- Create knowledge on biodiversity in deep-sea areas by integrating the biodistribution and environment data
- Estimate the distribution quantity of marine plastic wastes and understand the dynamic state
- Create knowledge concerning impacts on deep-sea ecosystems from disturbance due to human activities
- Work on providing relevant knowledge for evaluation of the impact of environmental changes on biodiversity for domestic and foreign relevant organizations and frameworks.

(2) R&D for sustainable and effective utilization of marine resources

Japan is a maritime state surrounded by the sea on all sides with a jurisdictional area about twelve times larger than the national land territory. The environment in this vast sea

area is rich in diversity: from subarctic in the north to subtropical in the south and what is more, from shallow sea to deep sea. Thus, Japan enjoys benefits in various ways. However, regardless of living or non-living creatures, it can still use only a small fraction of useful resources and functions available in the oceans. The Third Ocean Basic Policy says of the “Promotion of Industrial Use of Ocean”, the “Steady Promotion of R&D Related to Ocean Mineral Resource” and the “Promotion of R&D on Unknown Effective Functions and Genetic Resource, etc. under Extreme Environment such as Deep-Sea Area and Deep Sea Floor” In order to promote research and development of genetic resources etc.

For more efficient use of ocean resources, it is essential to 1) reveal unknown functions possessed by marine ecosystems by understanding the materials and energy circulations in the bioprocess, survival strategies and functions of deep-sea organisms, and 2) clarify the origin of useful mineral resources that may be related to non-biological processes such as hydrothermal activities, sedimentation, deposition, and chemical reaction, etc.

Therefore, in this project, the Agency will advance understanding of the origin of material circulation and useful resources in oceans from both biological and non-living points, and providing the obtained scientific knowledge, data, techniques, and samples to related industries that will contribute to sustainable use of the oceans. In addition, the Agency will work on R&D by using the knowledge obtained in this project and the one obtained in (1).

[1] Effective use of marine life and biological functions

To understand the material circulation in oceans in detail, the Agency will conduct chemical and molecular biological analysis, using samples such as marine life samples and geological samples, clarifies the environmental, physiological and evolution backgrounds that control environments as well as quantitatively identify the state of ocean biological resources. The Agency also will clarify specific functions obtained by living creatures while adapting to the extreme environment of the deep sea. The Agency will also promote collaboration and cooperation with related industries, universities, public research institutions, etc. and return the scientific knowledge, data, techniques, and samples obtained in these R&D to the society.

Specifically, by FY2021, the Agency will:

- Develop methods for quantitative and high-precision analysis of isotops of various organic compounds included in natural samples of marine lives in order to understand the structures of ecosystems and their material circulations.
- Develop methods for quantitative and high-precision analysis of isotops of various organic compounds included in natural samples of marine lives in order to understand the structures of ecosystems and their material circulations.
- Develop technologies to conduct isolation culture of microorganisms and analyze

metabolic functions while recreating the extreme environment.

- Create knowledge by applying the above-mentioned technologies to new microorganisms with unknown metabolic functions.

Furthermore, based on these progresses, by FY2025 the Agency will:

- Create knowledge necessary for the effective use of living marine resources by understanding the relationship with marine ecologies and the material circulation in detail
- Create knowledge concerning unknown effective functions such as metabolic functions and nanostructure functions specific to deep-sea organisms by analyzing genome information in collaboration with the mathematical science worked on in (4), and

Actively provide the obtained scientific knowledge, data, techniques, and samples to related industries in order to promote their industrial uses.

[2] Efficient use of seabed resources

The Agency has worked individually on field studies, collecting samples and analyses, data analyses, numerical model development to clarify the formation process of seabed resources. As a result, people understand the influence of chemical processes such as elemental concentration in a very wide space-time scale and the complicated physical processes including separation in a phase change from a disperse phase to condensed phase. Therefore, the Agency will conduct seamless research to find correlations between chemical and physical processes, build seabed resources generation models based on the obtained scientific knowledge and conduct R&D to theoretically predict promising sea areas. In addition, by widely deploying obtained knowledge and techniques to related industries, the Agency will contribute to the development of related industries.

Specifically, by FY2021, the Agency will:

- Develop exploration techniques aiming at more efficient and elaborate investigation and analysis with lower costs
- Measure property the chemical composition, species, isotopes, and era, and systematize the interactions between Earth's interior and oceans and material circulations.

Furthermore, based on these progresses, by FY2025 the Agency will:

- Clarify changes of marine environments and mineral formation process of resources in detail in 4-dimensional mappings of spatial scales and the time variation of the seabed resources and their surrounding environment by analyzing the various data obtained and various space-time scales

And at the same time, the Agency will generate resources and predict distribution by building models including mathematical science knowledge in collaboration with (4) and

provide scientific knowledge, data, techniques, etc. to industries.

(3) R&D on earthquakes and volcanoes in sea areas

In recent years, Japan was hit by earthquakes: the Hyogo Prefecture Nanbu Earthquake (1995), The 2011 off the Pacific coast of Tohoku Earthquake, the 2016 Kumamoto Earthquake, and the 2018 Hokkaido Eastern Iwate Earthquake and suffered a lot from accompanying tsunami. In addition, Japanese are concerned about the sudden disasters caused by the sea volcanoes including Kikai Caldera. Tsunami accompanying major volcanic eruptions is also a serious risk.

Therefore, in collaboration with relevant organizations such as universities, the National Research Institute for the Earth Science and Disaster Resilience, etc., the Agency carries out investigations and observations on sea earthquakes and volcanoes to identify and clarify the current status of their activities by using research vessels, various types of observation equipment, etc., in an assumed earthquake focal region of the Nankai Trough, where Japan is concerned about return of an earthquake, and in ocean areas around Japan and the Western Pacific area. The Agency will also improve the analyzing of data obtained by these observations, and forecast the changes of earthquake and volcano activities by conducting a large scale high-precision numerical simulation.

In this issue, the Agency contributes to the disaster mitigation by providing scientific knowledge obtained through these efforts with bearing the SDGs Goal 11 (Sustainable Cities and Communities) in mind, tries to deploy investigation and observation to other countries which suffer from many disasters from earthquakes, tsunami, and volcano activities like Japan, and apply research results.

[1] Understanding the actual conditions of ocean seismic zones by oceanographic observation

In comparison to earthquakes in land areas, we are still far behind in understanding the existing conditions of those occurring below the sea beds. Therefore, the Agency develops and deploys the seafloor crustal deformation/seismic activity observation technology systems to obtain real-time wide-area and detailed observation data to understand the present state and clarify the actual situation of earthquake activities. In particular, the Agency will conduct three-dimensional surveys of crustal structures, crustal activities, fault physical properties, and earthquake activity history mainly in sea areas with more urgency and importance as sources of massive earthquakes and tsunami. The Agency will widely provide data so that various types of data set obtained by these observation systems and investigations may be used by the relevant organizations in Japan including the Headquarters for Earthquake Research Promotion. In addition to knowledge obtained around Japan, a wide-area joint research system will be built to clarify existing conditions

of earthquakes and tsunami in the Asia-Pacific region and promote disaster risk reduction researches.

Specifically, by FY2021, the Agency will work on:

- Sea area verification tests in areas where the Dense Oceanfloor Network system for Earthquakes and Tsunamis (DONET) is installed for the advancement of seafloor geodetic observations
- The development of unmanned automatic observation technique to efficiently conduct new seafloor geodetic observation/ seismic observation technique including optical fiber sensing
- Three-dimension structure exploration and seabed earthquake observation understand the complicated fault shapes and various types of properties near the faults in important sea areas including the Nankai Trough
- Investigation of earthquake occurrence history by extraction and analysis of seabed sediment samples.

Furthermore, based on these progresses, by FY2025 the Agency will work on:

- Wide-area deployment in sea areas, etc., where DONET, the continuous real time seafloor geodetic observation system, is installed
- Detailed structure exploration and seabed earthquake observation, and investigation of wide-area structures and crustal activities in Kuril–Kamchatka Trench and Japan Trench, from where there have not been sufficient data
- Establishment of earthquake history investigation methods based on seabed sediments and apply them to important sea areas.

In addition, the Agency will analyze data obtained in the above-mentioned investigations and observations and provide the results to the Government of Japan, local governments, and relevant organizations as the knowledge on understanding the existing conditions in seismic zones.

[2] Understanding and predicting the occurrence process of earthquakes and tsunami

The Agency accumulates knowledge in order to contribute to the current understanding of the earthquake occurrence mechanism and the predicted changes of plate adhesion based on the latest data obtained from investigations and observations of the seismic zone. To this end, first of all, the Agency integrates various data obtained in [1] and the existing data, etc., refines the ocean seismic occurrence zone model developed so far by the mechanism, and calculates theseismogenic zone fluctuation by using these models. It establishes methods to understand the present state and forecasting transitions by analyzing the results and observation data. At the same time, the Agency will keep on upgrading the immediate tsunami damage prediction system built so far. The Agency will

transfer the obtained knowledge as information so that the GOJ can estimate the earthquake and tsunami damages, and will evaluate the present situation. It will disseminate information to the society in collaboration with (4).

Specifically, by FY2021, the Agency will:

- Build the 3D ocean seismic zone subsurface structure model by using data obtained by the new observation system, investigations, observation, and experiments
- Increases precision of data assimilation methods to understand and predict the changes of situation of crustal activities in ocean seismic zones.
- Upgrade the immediate tsunami damage prediction system by taking into account the sources of tsunami other than earthquake including submarine landslide.

Furthermore, based on these progresses, by FY2025 the Agency will work on:

- Upgrading the 3D ocean seismic zone subsurface structure model; simulation on processes such as earthquake occurrences by using this model, propagation of seismic waves, and tsunami occurrences; data analysis of crustal activities
- Modeling of dynamic processes of the fault movement based on dynamic experiment results using actual fault samples produced by drilling
- Trial of transition prediction of plate adhesion status by using data assimilation method
- Social implementation of the advanced tsunami damage prediction system in collaboration with relevant organizations including the National Research Institute for Earth Science and Disaster Resilience (NIED).

Furthermore, the Agency will enhance understanding and prediction of the earthquakes and tsunami generation process, and will submit acquired knowledge and data to the GOJ and relevant organizations.

[3] Understanding the status of internal activities of the earth as volcanic and global change factors

Undersea volcanic eruptions cause abrupt and large-scale disasters and exert great impact on the global environment. To predict occurrence of these volcanic disasters and evaluate their impacts on the global environment, it is necessary to understand the causes of heat, magma, and fluid generation and transport phenomena that are the cause, eruption history and prediction, and the internal activities of the earth, which prepare the process. Therefore, on this issue the Agency will promote offshore drilling using the Deep-sea Scientific Drilling Vessel Chikyu, etc. under the International Ocean Discovery Program (IODP) and will grasp the current status of activity history, past volcanic eruption types, etc. by observing the submarine volcanic activities, investigating, and sampling analysis of the geological samples. Furthermore, the Agency estimates the inner structure of the earth and material balance, etc. by using obtained data and analysis and clarifies internal fluid of

the earth, energy circulation mechanism, magma supply mechanism etc. from a single volcano to the global scale.

Specifically, by FY2021, the Agency will:

- Develop the sea area volcano observation system combining the unmanned automatic observation system and the sea area volcano observation system
- Work on structure explorations, seabed investigations for volcanic bodies, and collect rock samples
- Provide data and knowledge that contribute to predict submarine volcano activities to the GOJ and research institutions including universities. The data can be obtained based on the current status of volcano activities, process and mode from generation of magma and fluid to eruption.

Furthermore, based on these progresses, by FY2025 the Agent will work on:

- To understand the current status of volcano activities by using the sea area volcano observation system in the submarine volcano such as Izu-Ogasawara Arc
- Work on the comparative verification between the medium and long-term activities of volcanoes and the eruption processes in Japan and abroad using knowledge accumulated from continuous implementation of various types of investigation and observation, collection and analysis of samples
- Create data and research results to enable offshore drilling aiming at clarification of the actual conditions of the deep part of volcanic bodies and the oceanic crust by using “Chikyu”, etc.

(4) R&D for the enhancing and optimizing marine geophysics information using mathematical method

In this subject, in order to promote the understanding of mutual relationship between changes in the Earth system, which shows very complicating behaviors, and human activities, the Agency will develop methods that sequentially integrate all data obtained in (1), (2), and (3) R&D processes and mathematical analysis methods that enable integrated large data to be processed efficiently and optimally, and conducts R&D to find mutual relationship. These executions enable the Agency to extract unknown causal relationships in the Earth system (relationship between crustal activities intervening environmental changes and ecosystem changes, etc.) as well as utilize the obtained analysis results and aim at creating optimized information in accordance with various users’ needs from the new viewpoints.

Therefore, the agency works on 1) R&D of methods concerning diversified numerical analyses and their verifications, 2) R&D for creating information using those numerical analysis results, and 3) maintenance and operation of the execution framework equipped with the functions to be executed.

The Agency will also contribute to solving political issues and developing sustainable social economic systems by widely transmitting the information optimized for users' needs as described before. The goal is to build a framework to create more advanced and useful information by trying to extend this Agency to related domestic and foreign relevant organizations.

[1] R&D on numerical analysis and its verification method

The Agency will develop data conversion tools to unify the standards for integrating data with a totally different spatiotemporal scale to a wide variety of phenomena that make up the Earth system. In addition, to process data mathematically, which can be coordinated by the standardization, the Agency will develop the large-scale numerical analysis foundation system numerical analysis repository, "which aggregates various types of numerical analysis methods including advanced functions represented by artificial intelligence as well as the time evolution calculation, data assimilation, etc. In addition, the Agency will also develop verification technologies as a part of repository development to assure the quality of numerical analysis.

Specifically, by FY2021, the Agency will work on:

- Grand design of the "numerical analysis repository", development of multiple numerical analysis methods and conversion tool for unified standard, and verification of the usefulness by using the data group of the Agency
- Development of verification methods to ensure the quality and the reliability for numerical analysis results.

Furthermore, based on these progresses, by FY2025 the Agent will work on:

- Further upgrading and enhancement of the Agency's data integration, numerical analysis methods and their verification techniques
- Collaboration with users and relevant organizations in Japan and abroad a to upgrade and enhance "numerical analysis repository."

[2] R&D related to advanced and optimal information creation by using numerical analysis results

In addition to efficiently accumulating and controlling data output by the "numerical analysis repository," etc. and developing the large-scale data system "Four-Dimensional Virtual Earth" with advanced data analysis functions, the Agency will also develop a large-scale data system develop "four-dimensional virtual earth" equipped with advanced data analysis and analysis functions. We will also discover and clarify the interrelationship of the complex Earth system, and create optimized information in accordance with the users' needs based on the clarified mutual relationship, and provide more valuable information to the society. As for this system, the Agency will promote the development in

cooperation with the users of “industry - university - government”, implement an interface that allows the users to create information, and take social utilization into consideration, and will develop four-dimensional information visualization content.

The “Four-Dimensional Virtual Earth” is a concrete example that assumes linkage with the “numerical analysis repository.”

Specifically, by FY2021, the Agency will work on:

- Information creation related to impacts of seismic ground motions on life-lines, transport networks, industrial zones, etc. by numerical analyses using the 3D ocean seismic source zone subsurface structure model in (3), aiming to contribute to preparation for the Nankai Trough Earthquake
- Creation of information such as correlation between climate and weather conditions and epidemic risks which may increase or decrease in specific species, and the relationship between the great meandering of the Black Current, changes in the sea temperature and changes in the distribution of ocean biological resources.

Furthermore, based on these progresses, by FY2025 the Agent will work on:

- Expand constructible information through cooperation with users to create advanced and optimum information and make social disclosure sustainable
- Promote data integration with domestic and foreign relevant organizations, aiming at further upgrading and optimizing information.

[3] Development and operation of the optimal execution framework for information creation

To efficiently realize the task efficiently, the Agency will establish a high-speed network to connect with a high speed computer system, a data server, and so on, with functions suitable to handle large data as an execution framework of the “Numerical Analysis Repository” and the “Four-Dimensional Virtual Earth.” The Agency will develop and operate the execution frameworks in consideration of mutual sharing with Japanese and foreign institutions, focuses on compatibility after ensuring security, and facilitate acquisition of more users by easier coordination with other institutions. This will contribute to promoting the advancement and enhancement of the “Numerical Analysis Repository” and the “4D Virtual Earth.” Therefore, by FY2021, the Agency will consider the most suitable hardware, work on improvement, etc., and by FY2025, and work on the establishment of more stable operation systems of execution frameworks, improvement of convenience, and promotion of data integration with Japanese and foreign institutions.

(5) Challenging and original R&D and development of advanced fundamental technologies

Most of vast marine spaces from marine surfaces to deep sea floor and its subterranean

spaces are still a blank area for R&D by human beings. Moreover, the extreme environments in the deep sea, icebound polar areas, and seabed under them are exactly the last frontier left on the Earth. The Agency will work on challenging and developing advanced fundamental technologies to contribute to the creation of mankind's intellectual assets and new innovations by building scientifically and technically intellectual foundation to challenge these frontiers and develop new fields and promoting their use by inside and outside of the Agency.

[1] Promotion of challenging and original R&D

In this issue, the Agency will actually build the intellectual base for science and technology to create leap knowledge and innovation that support the “maritime state Japan” in the future by working on the following challenging and unique R&D for the marine space, which is an ultimate environment with invisible regions that extends beyond the remotely observed Universe. The Agency will arouse interests of Japanese of all ages in science and technology and will thereby greatly contribute to the promotion of science and technology policies in Japan through challenging and creative approaches and the results obtained from them. Furthermore, this issue means not only the aspect of investing in the future that will lead to the creation of leaps and bounds of innovation in 10 - 20 years, but also taking advantage of its characteristics as well, each individual R&D in (1), (2), and (3) that will promote collaboration between these two different fields, and will work to accelerate problem solutions, thereby contributing to the maximization of R&D results and improving scientific values.

[A] Fundamental, challenging and original research based on flexible and free ideas

In this issue, the Agency will work on highly uncertain but challenging and unique research by creating dramatic results such as leap outcomes and systematic understanding that can lead to future academic paradigm shift as the maximum goal. In particular, by focusing on the promotion of researches such as understanding of the role of oceans in the “Birth of Life” and the “Co-Evolution between Life and Environments,” which are recognized as world-leading germinating and remarkably unique themes (Priority Theme (a)), and search of unknown microorganisms and clarification of their physiological functions in dark ultimate environmental ecosystems (Priority Theme (b)), the Agency will create outcomes that will make them the main stream of the related R&D and build academic fields that enable Japan to lead the world within this period of mid to long-term objectives.

Specifically, by FY2021, the Agency will:

- Provide “Birth of Life in Deep-Sea Hydrothermal Scenario,” by integrating the latest knowledge (a)

- Clarification of metabolic functions in “Archaea, Origin of Eukaryote” and “Photosynthesis or Electrochemical Synthesis Microbes that use electricity as energy Not related to Photosynthesis or Chemical Synthesis” (b),

Furthermore, by FY2025 based on these progresses, the Agency will:

- Present a full version of “Birth of Life in Deep-Sea Hydrothermal Scenario,” and establish it (a)
- Visualize a new oceanographic image approaching the origin and universality of the oceans in the solar system including the Earth (a)
- Clarify the metabolism and physiological functions of a “ Bacteria Dominating Ultimate Environments but Whose Forms and Functions Are Totally Unknown” and the “Protoza Considered as the Most Primitive Eukaryote” (b)
- Prepare artificial biological functions added with the functions of unknown microbes that have been searched, and create basic knowledge concerning the substance production system by adapting the electrochemical synthesis mechanism (b).

By these initiatives, the Agency will produce world’s most leading-edge science outcomes in the relevant fields and new academic areas and build challenging and unique R&D infrastructures.

(B) Challenging and creative technology development research to build the future marine science and technology

In this issue, the Agency will work on the challenging and unique technology development research with high uncertainty but not due to the extension of the existing technologies, aiming at the creation of outcomes that will innovate the marine science and technology. In particular, the Agency focuses on original technology development by combining new technologies such as measurements using laser and electrochemical processing, which have been seldom used in conventional investigations and observations but have been recognized as germinating researches, microfine areas, and ultra-high precision analysis (Priority Theme (c)), creates unique technology platforms within this period of mid to long-term objectives, and build new technologies to support future conventional marine R&D.

Specifically, by FY2021, the Agency will:

- Establish experimental techniques to recreate earthquake fault movements under high temperature and high pressure conditions, and establish new techniques concerning hydrothermal utilization through laser machining and electrochemical processing (C).

Furthermore, by FY2025, based on these progresses, the Agent will:

- Establish experimental technology concerning the analyses of physical/chemical reaction processes in earthquake faults in source areas and subducting slabs, technology to identify living creatures by using underwater laser, and high-accuracy

processing technology for standard samples (C).

These will manifest the goals of brand new technology development to pioneer the future marine science researches.

[2] Development of advanced basic technology and operation of the marine survey platforms

The Agency will maintain and improve survey and observation capabilities through the technical development, improvement (function and performance enhancement), maintenance, development, and operation of marine survey platforms to contribute to maximize the R&D achievements of the Agency and the projects promoted by the GOJ including the “SIP Innovative Deep-Sea Resource Survey Technology.” In particular, sea areas with 7,000 m or deeper depth, sea areas with complex topography, sea areas with increased earthquake and volcano activities, hydrothermal areas, etc. are important areas of studies mentioned above. It is important to improve the safety and precisions, and enhance efficiency of investigations and observations in these areas. Therefore, the Agency will develop maritime robotics such as automation, labor saving, and downsizing, and will promote the development and implementation of the next-generation remotely operated vehicle system corresponding to various types of observation activities. Furthermore, the Agency will promote the technical development and its verification of very deep water and deep underground drilling technology in phases in collaboration with (3) and other R&D challenges to clarify the massive earthquake occurrence mechanisms, and the explorations and functions in the seabed underground biosphere, and to conduct mantle drilling, etc. in the future. Furthermore, the Agency will promote smart oceanographic surveys, observations, and operation by collaboration and cooperation with various relevant organizations in Japan and abroad for the technology development of marine survey platforms, introduction of advanced technologies such as the above-mentioned technology development and ICT, and the integration with existing methods and techniques.

The Agency will contribute to the achievement of marine policies in Japan such as ensuring safety and comfort in the oceans including the Maritime Domain Awareness (MDA) through these efforts.

(A) Marine research platform related technology development

It is required to ensure verifiable and high-accuracy observation and investigation capabilities, and properly understand and monitor the conditions in the sea area in order to relate them to the marine-derived social tasks based on scientific knowledge and data. Therefore, remotely operated vehicle systems including autonomous types should be implemented to correspond to wide areas and those in deep waters in accordance with the

proposals in “Ideal Deep-Sea Exploration Systems in the Future” (the Next-Generation Deep-Sea Exploration System Committee, Subdivision on Maritime Science, Ministry of Education, Culture, Sports, Science and Technology (MEXT) (August 2016). Highly versatile systems will be realized in collaboration with other institutions while confirming the trends in Japan and abroad at the time of implementation. Furthermore, on the basis of results by the manned exploitation vehicle, the development of next-generation manned vehicles will be continuously considered.

Specifically, by FY2021, the Agency will:

- Establish the remotely operated vehicle (ROV) technology, which can investigate sea areas with water depth exceeding 7,000 m, and
- Develop the autonomous underwater vehicle (AUV) technology, which can investigate in deeper water.

Furthermore, by FY2025 based on these progresses, the Agent will:

- Establish AUV technology available for the wide-area and comprehensive investigations
- Study and test these techniques aiming at completely unmanned investigations and observations.

In addition, over this period of mid to long-term objectives, the Agency will improve and develop widely basic and general observation systems and sensors, etc., based on characteristics of systems, promote the development of technology for automation, power-saving, downsizing, etc. for achieving high precision and efficiency, and will become the core marine frontier technology development base in Japan.

(B) Deepwater and deep drilling technology development

It is important to establish such technologies for clarification of massive earthquake occurrence mechanisms, exploration and function of the seabed subterranean biosphere, and to conduct mantle drillings in the future. Therefore, while understanding those scientific needs and extracting necessary technology development items, the Agency will formulate a practicable development plans and implement them in stages.

Specifically, by FY2021, the Agency will produce test units of more than one type of equipment and conduct verification tests in the shallow sea area to verify their performance and build a hearing system. Based on the progress, by FY2025, the Agency will make steady progress such as test boring in the candidate sea areas for hard rock drilling in very deep water and deep underground with newly developed equipment. In addition, over this period of mid to long-term objectives, the Agency will work on fundamental technology development related to other drilling.

(C) Development, operation and technical improvement of the oceanographic survey

platform

For the marine survey platforms possessed by the Agency, it will work on continuous improvement of functions, considering the age and service life of platforms to operate them with safety, laws and regulations in response to requests from the R&D and society. Therefore, the Agency will conduct smart oceanographic surveys, observations, and operations by trying to integrate the existing measures and technologies, technologies developed in (A) and (B), and advanced technologies. The Agency will also build efficient maintenance and management measures through the adequate monitoring of operational status. While realizing efficient operations with these approaches, the Agency will try to secure the optimum number of operating days of the research vessels necessary to achieve each plan in cooperation with other R&D issues. As for Chikyu, the Agency will operate it in accordance with the ocean discovery program formulated by the Agency through reviews and advices from the Chikyu IODP Board (CIB) under the IODP's international framework.

To contribute to the smooth creation of R&D outcomes, the Agency will provide scientific and technical supports to the users of marine survey platforms, and will continuously mature and improve them, and expedite the provision of quality control of obtained data, etc.

Specifically, the Agency will maintain and control the research facilities on a research vessel, formulate a research navigation plan, support measurement, collect samples, and analyze on a research vessel, and contribute to high-quality science data acquisition and outcome creation. As for an obtained high quantity of data and samples, the Agency will properly store, manage, and operate them in collaboration among the related departments in the Agency. In addition, the Agency will disseminate the activities and results in Japan and abroad in collaboration with relevant organizations to foster and expand the users of the marine survey platforms

2. Formation of a core institution for marine science and technology

The Agency aims at strengthening Japanese R&D capabilities by promoting fundamental R&D as shown in the preceding paragraph, as a core institution of marine science and technology in Japan, actively providing scientific knowledge to relevant organizations to solve social, political and global issues. Besides, by providing the above-mentioned knowledge and playing a leading role in an international project and a joint research with the non-Japanese institutions, the Agency aims at improving its presence as a core institution of marine science and technology not only in Japan but also in the global society. Therefore, by building strategic collaboration and cooperation relationship with universities, public research institutions, relevant ministries and agencies, private companies, local governments, etc., as well as strategically using the R&D

outcomes and intellectual properties in the Agency, it steadily promotes social return of these outcomes. Besides, the Agency will create new values with the society by contributing to enhancement of Japanese understanding of the marine science and technology, promotion of cross-sectional personnel exchange, and development of younger human resources that bear responsibility for further development of the marine science and technology in the future.

Furthermore, with an aim of the maximization of R&D achievements, the Agency utilizes its strength as a comprehensive research institution engaged in the marine science and technology, understands social and political needs, promotes the simultaneous use of large R&D facilities such as various types of marine survey platforms, computer systems, etc., possessed by the Agency, and work on the enhancement of the use of obtained data and samples.

(1) Promotion of social return of R&D outcomes through closer collaboration with related organizations

[1] Promotion of collaboration and joint efforts among industries, universities, and the government and uses of R&D results

The Agency will promote the solution of social and political issues including Society 5.0 and the activation of industries by using its knowledge obtained in the processes when it aims at creating scientific outcomes. In the promotion, the Agency properly understands and manages intellectual properties such as scientific papers and patents. Furthermore, the Agency will enhance and make targetable intellectual properties complete by the management and use of knowhow, ideas, etc., and in-house development of strongly intentional germinating R&D. Furthermore, the Agency will target at the development and enhancement of intellectual properties and improvement of appealing effects by implementing joint projects through the collaboration with the GOJ, local governments, universities, research institutions, private companies, etc., and actively participating in personnel exchanges of researchers and engineers, information exchange, exchange meetings (including those implemented by the Agency itself).

These activities will be realized as outcomes in timely manner leading to strengthening the R&D capabilities in the related fields based on characteristics of individual usage targets including licenses such as patents, venture start-up, and provision of various types of created contents. In addition, the Agency will target create a virtuous cycle of continuous scientific outcomes that links to the next R&D using various resources acquired by each method.

Furthermore, the Agency will further deepen collaboration and cooperation with initiatives for promoting marine industries, measures for developing human resources in each region promoted mainly by local governments and will steadily promote activities for

fruitful collaboration with private companies, etc.

[2] Promotion of the international cooperation

While improving the international presence of the Agency, as a core institution of the marine science and technology of Japan, will aim to contribute to the resolutions of global issues. Therefore, the Agency, while actively involved in various international frameworks such as relevant UN agencies, global projects, SDGs and the UN Decade of Ocean Science for Sustainable Development (2021-2030), will play a major role. Furthermore, it will build effective collaboration systems through joint researches and agreements with overseas marine research institutions to lead to the development of various marine science and technology fields and enhancement of Japanese R&D capabilities.

Regarding international scientific drilling programs including IODP, the Agency will keep on operating Chikyu in the current framework, cooperate and collaborate with Kochi University, store, manage, and provide the drilling core samples. Furthermore, to promote the participation in Japanese IODP, the International Continental Scientific Drilling Program (ICDP), the Agency will support researchers in Japan for their participation in IODP/ICDP through the Japan Drilling Earth Science Consortium (J-DESC), and will play a role of leading researchers' community. In addition, to carry forward a scientific drilling project using Chikyu, the Agency will improve the international recognition of Chikyu, disseminate its achievements, and increase the number of participating countries. In addition, the Agency will develop arguments on a framework succeeding IODP in and after October 2023 in coordination with the participating relevant organizations.

[3] Promotion of R&D through sponsored funds

To further promote R&D of the Agency and lead to further development of achievements, the Agency will actively apply for various types of public offering type researches implemented by the GOJ, incorporated administrative agencies and private companies, and will promote R&D through sponsored funds such as consignment costs, grants, and subsidies. In particular, the Agency will contribute to the development of Japanese marine science and technology fields through taking initiatives on the Japanese political tasks including the Strategic Innovation Promotion Program (SIP) and will actively introduce private capitals.

[4] Young Human resources development

To develop young resources and expand human resources in the marine science and technology fields, the Agency recognizes that each Agency employee should play an important role in the development of young resources. It will build a coordination system with other institutions including universities, and promote efficient and effective efforts

under a consistent strategy as an Agency. Specifically, the agency will perform the following initiatives while paying attention to the effectiveness of initiatives and working on the improvement and enhancement to deploy more effective human resource development initiatives.

- The Agency will accept young researchers, engineers, graduate students from Japan and abroad by building a coordination system with partner graduate schools and private companies and using a human resources development business promoted by the GOJ, will provide its excellent research development environment, and support the human resources for devoting themselves to R&D.
- While actively transmitting the Agency's efforts on the human resource development by using web sites, etc., the Agency disseminates information to recall the active career paths of researchers and engineers in the marine science and technology fields. Furthermore, the Agency will collaborate with high school education such as super science high school, etc., and actively provide opportunities to experience the marine science and technology, hoping for expanding human resources in the future.

[5] Promote the public relations and outreach activities

Taking into account the targets of disseminating advertisement, the Agency will conduct strategic public relation activities so that its efforts can be widely recognized and understood by the Japanese citizens such as solutions to social, political and global issues with its R&D and its marine science and technology.

- The Agency will use its public relations tools (including web sites), equipment, vessels, etc., and make ingenious efforts so that the Japanese can easily understand its R&D.
- For official announcements to the class, which the Agency finds it difficult to do publicity activities to by itself, it will work together with various external institutions regardless of sectors, such as, various media, companies, science museums, museums, aquariums, etc., and will make efforts in a way that both sides can expect synergetic effect.
- The Agency will make efforts to enhance understanding of the media through the timely press conferences, etc. as well as press releases.

(2) Promotion of sharing large research facilities and data, etc.

[1] Shared use of R&D infrastructures such as marine survey platforms and computer systems

The Agency offers marine survey platforms, computer systems, and other facilities and equipment to promote political issues including SIP while considering the promotion of its R&D and characteristic properties of R&D infrastructures. It will also actively contribute

to the common base that supports Japanese science and technology such as the innovative High Performance Computing Infrastructure (HPCI). Furthermore, in order to improve the marine science and technology, it will actively secure the sponsored public or private funds, and offer them to various industry - university - government institutions. Therefore, the Agency will work on improving the safer operations and convenience in these R&D infrastructures. In case of common use, it will contribute to the improvement of its presence as the global oceanographic survey observation center, paying attention to the global network development and demonstrating a leadership, etc.

[2] Cooperation of vessel operations concerning academic researches

Under a close partnership with the Atmosphere and Ocean Research Institute of the University of Tokyo, the joint use research center, the Agency will formulate a ship operation plan with an ensured ship time of around 400 days/year with special consideration on the features of academic research thereby efficiently operating the academic research vessels to improve the level of Japanese marine science and technology and the development of academic researches.

[3] Provision and promotion of usage of data and samples

To promote researches conducted in Japan and abroad, Japanese initiatives including MDA and international frameworks and projects, and contribute to the development of the global marine science and technology, the Agency effectively will provide information on various types of data and samples obtained by possessed R&D infrastructures, etc. In providing the information, the Agency systematically collects, sorts, analyzes, processes, and stores it and enhances their related techniques in accordance with basic policies on handling data and samples. Furthermore, as for the provision of data and samples, the Agency will make studies for optimization as needed by comprehensively taking users' needs, natures of data and samples, and security measures at the time of provision into consideration, revises and improves the related policies and systems, etc.

II Measures for achieving the objectives of improvement and efficient administrative operations

1. Establishment of a proper and efficient management system

(1) Management and internal control

The Agency further strengthens management and the internal control under the leadership of the Chief Director on the basis of the status of the Third Period for Mid Term Objectives and social conditions.

The Agency will manifest the policy of management enhancement in accordance with Japanese policies and various trends in Japan and abroad and will further promote

communication with employees in order to further improve the performance of R&D as a core institution of the marine science and technology. Furthermore, the Agency will administer the organization flexibly and actively to enhance collaboration among fields and departments in the Agency. With respect to business operations concerning R&D, JAMSTEC Advisory Board (JAB) meeting will be held within the Period for Mid to Long-Term Objectives to explain and discuss Agency's efforts, and receive advices and proposals from a global point of view. Furthermore, the Agency will regularly exchange views with outside experts and receives advices from political and management viewpoints.

As for the enhancement of the internal control, the Agency will further improve the efficiency of business operations, clarify a decision process, responsibilities and discretion, and ensure compliance in the organization and operations. On this occasion, the Agency understands the risks impeding achievements of Mid to Long-Term Objectives, will properly respond to risks in consideration of their impacts and continuously make efforts such as generation of awareness among employees at ordinary times to enhance effectiveness of the internal control including the compliance with laws and regulations. In addition, it will inspect whether the internal control system is properly applied through the internal audit, review results as required and reflect them in the organization and management. To prevent illegal actions and illegal use of research funds in R&D, it will promote effective measures to prevent illegal actions and illegal use of research funds such as the clarification of the system and persons in charge (PIC), and educational activities.

By comprehensively promoting these measures, it will realize proper management to achieve Mid to Long - term Objectives.

(2) Evaluation

Based on Mid to Long - term Objectives, self-evaluations are conducted for the "maximization of research and development achievements as an agency" and "Ensure appropriate, effective and efficient operations." On this occasion, the Agency will conduct timely evaluation and publicly discloses results based on the National Guideline on the Method of Evaluation for Governmental R&D (determined by the Prime Minister on December 21, 2016) and the Act on General Rules for Incorporated Administrative Agencies.

Besides, it will incorporate helpful indicators and external evaluations to self-evaluation keeping in mind that it is objective and highly reliable.

It will feed back the above described self-evaluation and result of the evaluation by the competent minister, circulate the PDCA cycle, and reflect it in the improvement of business operations. Furthermore, it will conduct an interim evaluation in the middle of

the target period, and reflect the results in business operations.

2. Rationalization and efficiency of operations

(1) Promotion of rational and efficient business operations

Taking into consideration of not compromising the R&D capability and safety, the Agency will work on faster decision making, computerization of business operations, rationalize and streamline business operations through appropriate allocation of human resources to efficiently carry out business operations of the Agency.

With regard to the projects to which operating expenses grants are allocated, efficiency will be raised to xx% or more compared with the initial fiscal year in the period of mid to long-term objectives for general administrative expenses (excluding personnel expenditure, mandatory expenses and taxes and public charges), and xx% or more compared with the initial fiscal year in the period of mid to long-term objectives for other expenses (excluding personnel expenditure) with the exclusion of new and expanding projects which are subject to efficiency improvement in the next fiscal year.

These will help the Agency create new projects in accordance with the political and social needs and effectively and rationally promote the social return of results.

The appropriateness of personnel expenses will be worked out in the next issue.

(2) Appropriateness of personnel expenses

As for salary levels, the Agency will carefully verify what salaries for the employees should be based on government policies, maintain proper levels throughout the organization in the light of salary levels of national public officers and special characteristics of the duties, and set flexible salaries to secure excellent Japanese and foreign researchers.

It will also disclose the verification results and the state of efforts publicly and will give explanations to gain understanding of the Japanese citizens.

(3) Appropriateness of contracts

Bearing the maximization of R&D achievements in mind, based on the “Policy for Streamlining Procurement by Incorporated Administrative Agencies” (Decision by the Minister for Internal Affairs and Communications on May 25, 2015), the Agency ensures the governance on procurement, fairness and transparency through PDCA cycle, and autonomously and will continuously work on streamlining procurements etc., taking into account of the characteristics of R&D works.

Furthermore, it ensures fairness and transparency through an inspection on contracts.

III. Measures for achieving improvement of financial conditions

1. Budgets, income and expenditure plans and fund plans

(1) Budget (Mid to Long-term Plan)

Fiscal 2019-2025 budget

(Unit: million yen)

| Category | R&D | Formation of core institution | Common to agencies | Total |
|---|-----|-------------------------------|--------------------|-------|
| Income | | | | |
| operating expenses grant | | | | |
| Grants for facility expenses | | | | |
| Grant income | | | | |
| Operating revenue | | | | |
| Revenue from entrusted business | | | | |
| Total | | | | |
| Expenditures | | | | |
| general administrative expenses | | | | |
| (general administrative expenses excluding taxes and public dues) | | | | |
| Personnel expenses (for management) | | | | |
| Impersonal expenses | | | | |
| taxes and public dues | | | | |
| Business expenses | | | | |
| Personnel expenses (for business) | | | | |
| Impersonal expenses | | | | |
| Facilities expenses | | | | |
| Subsidized business | | | | |
| Entrusted expenses | | | | |
| Total | | | | |

[Note 1] Values in integration and sum total columns may not match due to rounding off.

[Note 2] The budgets above are estimates based on rules on calculation of the operating expenses grant under certain assumptions. As for budgets in fiscal years, we shall consider the widely varied necessary expenses depending on the development of projects and determine them after recalculation in a budget compilation process of each fiscal year. The authority does a provisional estimate for tax and other dues in administrative expenditures but determines specific amounts after recalculation in a budget compilation process of each fiscal year.

[Calculation operating expenses grants]

(2) Income and expenditure plans

Fiscal 2019-2025 income and expenditure plan

(Unit: million yen)

| Category | R&D | Formation of core institution | Common to agencies | Total |
|--|-----|-------------------------------|--------------------|-------|
| Expenses | | | | |
| Ordinary expenses | | | | |
| Business expenses | | | | |
| general administrative expenses | | | | |
| Funds in trust | | | | |
| Subject project expenses | | | | |
| Depreciation expenses | | | | |
| Financial expenses | | | | |
| Extraordinary loss | | | | |
| Income | | | | |
| Income from Management expense grant income | | | | |
| Revenue from entrusted business | | | | |
| Grant income | | | | |
| Other income | | | | |
| Reversal of per contra liabilities for property acquisition | | | | |
| Extraordinary income | | | | |
| Net loss | | | | |
| Reversal of appropriated surplus of the previous period of mid to long-term objectives | | | | |
| Reversal of appropriated surplus | | | | |
| Gross income | | | | |

[Note] Values in integration and sum total columns may not match due to rounding off.

(3) Fund plans

Fiscal 2019-2025 Fund plan

(Unit: million yen)

| Category | R&D | Formation of core institution | Common to agencies | Total |
|---|-----|-------------------------------|--------------------|-------|
| Fund expenditure | | | | |
| Expenditure from operating activities | | | | |
| Expenditure from investment activities | | | | |
| Expenditure from financial activities | | | | |
| Surplus carried forward to the next period of Mid to Long - term Objectives | | | | |

| | | | | |
|--|--|--|--|--|
| Fund income | | | | |
| Income from operating activities | | | | |
| Management expense grant income | | | | |
| Grant income | | | | |
| Revenue from entrusted business | | | | |
| Other income | | | | |
| Income from investment activities | | | | |
| Income from facility expenses | | | | |
| Income from financial activities | | | | |
| Surplus carried forward from the previous medium-term objectives | | | | |

[Note] Values in integration and sum total columns may not match due to rounding off.

2. Limits of short-term borrowing

Limits of short-term borrowing shall be 11.3 billion yen.

A short-term borrowing is assumed to be due to the delay in accepting the operating expenses subsidy and temporary repayment of expenses for the consignment business.

3. If JAEA has any unnecessary property or any property that is expected to be unnecessary, a plan for disposal of such property.

There is no plan concerning unnecessary property or potential unnecessary property.

4. The plan to assign or mortgage important property other than the one provided in the previous item.

There is no plan to assign or mortgage important property other than the one provided in the previous item.

5. Usage of surplus account

If surplus occurs in a settlement of the Agency, the surplus should be used for a focused R&D business, business required for activities as a core institution, expenses for maintaining research environments, management of intellectual properties, and technology transfer, to enhance employee training, systematize business operations, and enhance public relationship conducted as the Agency.

6. Debt burden exceeding the mid to long-term objective period

The debt exceeding the period for medium to long-term objectives shall be assumed if the R&D infrastructure development, etc. exceeds the period for mid to long-term objectives, and the debt burden is judged as reasonable in consideration of its necessity and the influence on a funding plan.

7. Financial reserve and usage

If funds are reserved after accounting according to Article 44 of the Act on General Rules for Incorporated Administrative Agency in the final fiscal year of the previous period for mid to long-term objectives, the money equivalent to the amount approved by the competent minister is appropriated to the following:

- (1) Expenses for business operations required for focus R&D business and activities as a core institution, those for developing research environment, those for management of intellectual properties and technology transfer, those for employee education, those for systematizing business operation, and those for public relation, which are stipulated for the use of surplus in a mid to long-term plan
- (2) Account treatment concerning the amount equivalent to unamortized balance of the fixed asset obtained from self-generated income

IV Other Important Matters concerning Administrative Operations

1. Ensuring and enhancing people's reliability

Agency provides information in accordance with the Act on Access to Information Held by Incorporated Administrative Agencies (Act No. 145 of 2001).

Furthermore, Agency properly handles personal information in accordance with the Act on Access to Information Held by Incorporated Administrative Agencies (Act No. 59 of 1960).

Every day, new cyber attack methods are revealed. The Agency will continuously promote the maintenance of information system infrastructure and environment in accordance with “Common Standards of Information Security Measures for Government Agencies” on the basis of the latest technical trend and promotes the information security measures through education and compliance of information ethics.

In performing business operations, the Agency will properly develop regulations on safety, etc., shares technical information and knowhow necessary for the accident trouble information and security, and pay due consideration to security.

2. Matters concerning personnel affairs

To correspond to social and political issues with the marine science and technology, The Agency will promote efforts to improve human resource quality and class and ensure excellent human resources in Japan and abroad. Furthermore, the agency improves the motivation of employees and creates a good environment to correspond with diversified work styles.

Specifically, the following efforts are implemented:

- The Agency will ensure and develop excellent and diversified human resources with high professionalism, holistic perspective, and leadership according to the plan.

- By using the cross-appointment system, the agency will promote efforts to ensure excellent human resources in Japan and abroad.
- The Agency will promote individual career development, the gender equality, work–life balance, develop a work environment where employees can easily work and fulfill their potentials, and promote various, flexible, and productive work styles for every employee by a personnel distribution in accordance with the business situations, proper evaluation and treatment to increase motivations of employees, systematically support trainings in accordance with capabilities and intentions of employees.

3. Matters concerning facilities and equipment

It is necessary to suitably maintain, operate, and effectively use facilities and equipment to always improve and maintain good research environments.

Therefore, the Agency not only will effectively use existing research facilities, facilities and equipment to be improved during the period for mid to long-term objectives but also properly implement the cycle of refurbishment-upgrade-improvement of facilities and equipment including countermeasures against their deterioration.