3.2 Strategic Priority Setting in Science and Technology

3.2.1 Promotion of Basic Research

Basic research, bringing human wisdom and serving as a source of knowledge, is an activity accumulated as a property shared by all mankind. It is realized in the steady, serious pursuit of truth and after much trial and error. The findings and inventions, which do not fall into the existing knowledge framework, will make leaps in knowledge. It is thus important to nurture innovative spirits among researchers. Basic research consists of two types: (1) academic research based on the free ideas of researchers, and (2) basic research that aims at future applications based on policies. It is necessary to understand the purpose of each of these types and should be widely, steadily, and continuously promoted.

To this end, we are promoting basic research at universities and other institutions by securing basic research funds such as national university budget subsidy and financial aid to private educational institutions as well as through competitive funds, such as Grants-in-Aid for Scientific Research for (1) and Creative Research for Evaluation Science and Technology Program of the Japan Science and Technology Corporation for (2).

3.2.2 Priority Setting in Research and Development for Policy-Oriented Subjects

It is essential to strategically prioritize research and development in response to policy challenges in addition to promoting basic research, which is "investment for tomorrow," in order to maximize the effects of governmental R&D expenditure under the 3rd Science and Technology Basic Plan. The four priority fields in the 2nd Science and Technology Basic Plan (life science, information and telecommunications, environment, nanotechnology and materials) are made into "four priority promotion fields," in the 3rd Science and Technology Basic Plan, based on the level of contribution to the three ideas, strategic viability, the trends of science and technology strategies in the world, and public expectations. Resources are allocated to these fields with high priority. In addition to the above, the 3rd Basic Plan also deems the other four areas including energy, MONOZUKURI technology, social infrastructure, and frontier as those in which research and development activities are conducted with an emphasis on issues that are fundamentals for the nation's existence and need to be addressed by the government (hereinafter "four fields to be promoted"), and resource allocation will be made in an appropriate manner based on the principles of intra-sectional prioritization.

[Establishing Promotional Strategies for Each Field and Selecting Science and Technology Fields for Strategic Priorities]

Prioritized resource allocation should not be made, without close examination, to research and development projects, even to those relating to the four primary priority areas. Also, it is not appropriate to remove research and development projects relating to the four priority areas, without such examination, from subjects for strategic resource allocation.

Therefore, based on the 3rd Science and Technology Basic Plan, Council for Science and Technology Policy has established Promotion Strategies for Each Field (decided at the meeting of Council for Science and Technology Policy on March 28, 2006) with goals of selecting and concentrating the investment during the period of this plan as well as the research results. In these Promotion Strategies for Each Field, a total of 273 topics were selected as "critical research and development topics" that the government should be involved in, from the perspectives of (1) future effect, (2) Japan's position and level in grovel science and technology, (3) contribution to achieving policy goals, and (4) the necessity of investments based on the role of the public and the private sectors. For each project, research goals and result goals were clearly stated. Among these "critical research and development topics," 62 "Strategic Prioritized Science and Technology" projects were chosen as subjects of priority funding; they are projects (1) in which social and public concerns or needs that have been rapidly growing must be promptly answered within the next five years, (2) for which intense funding for the next five years is indispensable for international competition and the development of innovations, and (3) which are long-term, large-scale, government-led, strategic projects that require intense funding ("Key Technology of National Importance"). These are clearly stated in the Promotion Strategies for Each Field.

3.2.2.1 Life Sciences

The life sciences aim at elucidating the complex and elaborate mechanisms of biological phenomena produced by living things, and their results contribute greatly to the improvement of people's lives and to development of the national economy, through dramatic advances in medicine, resolutions of food supply and environmental problems, and other areas.

In the Field-by-Field Promotion Strategy, for the field of life sciences, the following seven strategically emphasized science and technology projects are listed as those requiring intense funding for the next five years. MEXT and other government ministries are promoting research and development centered on these strategically emphasized science and technology projects.

(1) Basic and generic research themes which support life sciences research as a whole

(i) Science and technology for the reproduction of the program of life

a) Genome-related research

Based on the completion of detailed sequencing of the human genome, the Ministry of Education, Culture, Sports, Science and Technology started the "Genome Network Project" in Fiscal 2004. This project aims to elucidate basic problems relating to life sciences, elucidate the mechanisms of disease development, and

develop new treatment methods by clarifying the network that establishes vital activity mainly through comprehensive analysis of the interactions of biological molecules, etc. In addition, research has been steadily promoted in such fields as the analysis of protein structures and functions related to genome-based drug discoveries, etc., and the development of revolutionary medical technologies that make use of individual genome information.

The Ministry of Health, Labour and Welfare has been promoting R&D for the establishment of methods for the prevention, diagnosis and treatment of disease and the development of revolutionary new drugs by elucidating genes related to dementia, cancer, diabetes, high blood pressure, asthma, and other ailments of the elderly. Moreover, taking into consideration rapid advances in genomic sciences seen in recent years, research and development has been carried out since Fiscal 2002 into basic technologies (toxicogenomics) that allow rapid and effective prediction of the safety (toxicity, side effects, etc.) of compounds that are candidates for medical products.

METI is promoting R&D for developing tools (informatics and high-sensitivity quantitative analysis technologies) for analyzing functional RNA, as well as understanding its functions, by taking advantage of private-sector power through the New Energy and Industrial Technology Development Organization.

b) Promotion of protein structural and functional analyses

Analysis of protein structure and molecular function is one of the most important fields in post-genome research, because the research results can link directly to applications in medicine or to uses in industry.

Toward the goal of developing genome-based drugs in Japan, the Ministry of Education, Culture, Sports, Science and Technology has been promoting the "Protein 3000 Project" since Fiscal 2002, to elucidate the structures and functions of one-third (about 3,000) of the approximately 10,000 basic protein folds known to exist, and to transfer the research results, to include patenting the results, to industry. By December 2006, a total of 4,190 structures, exceeding the number initially targeted, had been confirmed.

c) Promotion of brain sciences research

Brain science is expected to lead to results that improve the quality of life, as well as to improved medical science and to the creation of new technologies and industries. The resulting efforts have greatly strengthened Japan's brain sciences research, which is divided broadly into the four fields of "understanding the brain," "protecting the brain," "creating the brain," and "strengthening the brain" through research and development that makes maximum use of the many universities and national research institutions that extend beyond the bounds of individual ministries and agencies.

The Ministry of Education, Culture, Sports, Science and Technology is promoting research at the Brain Science Institute at RIKEN, through the utilization of Grants-in-Aid for Scientific Research, for the high-priority promotion of brain science research at universities and colleges. Since Fiscal 2005, the ministry has been developing information infrastructure including an enormous amount of research results in brain neurochemistry, while promoting neuroinformatics to provide the results for researchers around the world as part of its international cooperation.

d) Promotion of research in cell/biodynamics simulation

Since Fiscal 2003, the Ministry of Education, Culture, Sports, Science and Technology has been conducting the Cell / Biodynamics Simulation Project, with the aim to simulate the analysis of drug responsiveness and animal tests conducted by using living bodies and cells, based on life information technology and advanced imaging technology.

e) Promotion of immunity and allergy research

MEXT is carrying out basic research concerning immunity and allergies at the RIKEN Research Center for Allergy and Immunology.

The RIKEN Research Center for Allergy and Immunology and the National Hospital Organization Sagamihara National Hospital has made a joint research agreement, and are promoting efficient research through collaboration between the basics and clinical applications.

f) Promotion of analysis of the functions of sugar chains

In regard to research on sugar chains, which are believed to play important roles in a vast array of biological functions, the Ministry of Education, Culture, Sports, Science and Technology is using the Grant-in-Aid for Scientific Research and Basic Research Programs to promote sugar chain research at universities and colleges. Furthermore, at the RIKEN Frontier Research System, researchers are constructing cells and studying the film domain (supra-biomolecular systems) made up of sugar chain structures and fat molecules that support the cell

functions in their research concerning functions whereby the body recognizes and communicates information.

METI is developing methods and tools for analyzing the functions of sugar chains and sugar proteins efficiently and carrying out R&D toward developing a mass-synthesis technology of sugar chains by taking advantage of the private-sector power through the New Energy and Industrial Technology Development Organization.

(2) Challenges in the field of "better living"

(ii) Clinical research; research for bridging the gap toward clinical application

a) Promotion of genetic polymorphism research

For the purpose of elucidating the causes of diseases and realizing effective personalized medicine the Ministry of Education, Culture, Sports, Science and Technology has been conducting the "Personalized Medicine Project" since Fiscal 2003. The ministry, with the cooperation of many other medical institutions, performed collection of DNA/serum samples and clinical information from targeted patients for the development of a bio-bank, and, by using these samples, it has been conducting full-scale research for the elucidation of the relationship between SNPs[1], diseases, drug responsiveness, and side-effects. The RIKEN SNP Research Center has been promoting research on the elucidation of the causes of diseases, in cooperation with this project.

b) Promotion of research on development, differentiation, and regenerative science

Research into development, differentiation, and regeneration in biological system aims to elucidate the mechanisms, etc. relating to the process in which one cell differentiates into various tissues or organs to form and maintain an individual. This serves as a basis for regenerative medicine, and the research of this field brings about rapid advances in stem cell research and establishment of technology for producing Embryonic Stem (ES) cells in recent years.

The Ministry of Education, Culture, Sports, Science and Technology is conducting research at the RIKEN Center for Developmental Biology. Moreover, in Fiscal 2003, the ministry launched the "Project for Realization of Regenerative Medicine" and has been promoting research towards developing a stem cell bank as research infrastructure in order to provide stem cells for researchers, and applying the results of basic research to clinical areas.

c) Promotion of molecular imaging research

Molecular imaging is a technique for visualizing quantities and functions of molecules in living organisms.

MEXT has been involved in the "Molecular Imaging Research Program" since Fiscal 2005, coordinating a central core for innovation in the drug discovery process with a research base for exploring new drugs (RIKEN), and for development of diagnostic technology with a research base for PET diagnosis (National Institute of Radiological Sciences), carrying out revolutionary R&D to improve the search for candidate materials for medicine creation and disease diagnosis at these centers, and promoting training of human resources.

METI has been involved in the "R&D of Molecule Imaging Equipment," also since Fiscal 2005. It has been developing a molecular imaging device that can detect cellular function changes with high sensitivity, accuracy, and speed so that tumors can be discovered and the level of malignancy can be diagnosed at early stages.

The Ministry of Health, Labour and Welfare is promoting the development of medical devices toward non-invasive and low-invasive treatment through applications of nanotechnology. It is also carrying out research in innovative imaging diagnosis technology and devices for treatment of cancer and other diseases. Some research projects are supported through matching funds with the New Energy and Industrial Technology Development Organization.

d) R&D that promotes implementation of research results such as making the medicine-creation process more efficient

METI is carrying out R&D toward the building of basic technology to accelerate "genome-based drug discovery," which produces new medicines using genetic information. This involves technologies that elucidate disease mechanisms at the genetic level using human full-length cDNA, which is one of the fields Japan is leading, technologies that efficiently create medicines based on disease mechanisms analyzed, technologies that efficiently create medicines based on membrane proteins' structure information that is considered to play a crucial role in living organisms, and technologies that create research model cells for diseases based from human ES

[1] SNPs: Single Nucleotide Polymorphisms. These refer to the phenomena that, in the base (DNA) sequences of the genome, different races and individuals (e.g., healthy people and sick people) have different bases; the term can also refer to the positions of these bases on the genome.

cells. In addition, the ministry is also developing technologies to create new antibodies that can be used in antibody therapeutics and diagnostics and to efficiently purify antibodies.

(iii) Innovative cancer treatment technologies such as targeted treatment

Based on the "The Third Term Comprehensive 10-Year Strategy Cancer Control" (established by the Minister of Education, Culture, Sports, Science and Technology and the Minister of Health, Labour and Welfare in July 2003), some new understanding of the mechanism of cancer and new methods for prevention, diagnosis, and treatment for cancer, taking advantage of related research results are being elucidated.

Since 2004, MEXT has been carrying out the project "Promotion of research toward the development of innovative cancer treatment, etc." as research that leads to clinical applications of outstanding results of basic research related to cancer-immunity treatment and molecular target treatment. The National Institute of Radiological Sciences is also promoting research in heavy ion cancer therapy, which is expected to be a revolutionary treatment method for types of cancer that are otherwise difficult to treat. In addition, research and development are under way, led by the National Institute of Radiological Sciences, to reduce the size of heavy ion beam radiation equipment for more popular use across the country. Based on the results of this research, Gunma University has been preparing a small heavy-ion beam radiation facility since 2006.

The Ministry of Health, Labour and Welfare is involved in research on the mechanism of cancer and translational research that widely applies the research results; multicenter clinical trials for the purpose of establishing standard treatment procedures for cancer treatment; research on palliative care for maintaining and improving quality of life among cancer patients and their families; research on cancer epidemiology and dissemination of cancer information; and research concerning policy challenges such as building a system for promoting equalization of cancer medical services nationwide.

Since 2005, METI has been conducting the "Project for R&D on a Next-generation DDS-type Malignant Tumor Therapy System" to develop molecular imaging devices that can detect cancer at a very early stage and to treat cancer cells (and only cancer cells) with pinpoint accuracy.

(iv) Science and technology for overcoming emerging and re-emerging infectious diseases

Currently, the society's fear for new and recurring diseases such as SARS and new types of influenza is increasing internationally.

The Ministry of Education, Culture, Sports, Science and Technology has been promoting research that targets the suppression of Severe Acute Respiratory Syndrome (SARS) and other infectious diseases. In Fiscal 2005, the ministry commenced the "Program of Founding Research Centers for Emerging and Reemerging Infectious Diseases" to promote research in emerging and reemerging infectious diseases at research centers both in and out of the country in its effort to integrate the basic knowledge and expertise concerning Japan's measures against infectious diseases and, through research activities, to train human resources.

It has become urgent for us to take measures to address newly discovered infectious diseases and diseases which were once under control but are running rampant again, as well as to take actions against infectious diseases including cooperation with domestic and international partners. Therefore, the Ministry of Health, Labour and Welfare is performing research with an added emphasis on the field of preventive and diagnostic technology, on-site studies and international measures for emerging and reemerging infectious diseases, animal-originated infectious diseases (zoonosis), and other infectious diseases. The National Institute of Infectious Diseases is carrying out a wide variety of leading, creative, and comprehensive research on infectious diseases.

(3) Challenges in the field of "better eating" and "better lifestyle"

(v) Science and technology for the production and supply of safe foods which will improve our nation's international competitiveness

With advances in genome science, the analysis of the structure and functions of plant genome are also progressing. It is expected that by controlling plant functions based on these results, we can develop plants that will contribute to improved eating life.

The Ministry of Education, Culture, Sports, Science and Technology is promoting research to improve plant productivity in terms of both quality and quantity, through the genome sequencing of Arabidopsis thaliana etc. at the RIKEN Plant Science Center, and the level of research carried out is on par with that of the United States and Europe.

The Ministry of Agriculture, Forestry and Fisheries has decoded all base sequences of rice genome in the research on rice genome, which is the basis of research on all crops such as main grains, and the ministry is promoting the understanding of functions of usable genes along with obtaining patents for them, gaining international recognition for its work.

In Fiscal 2005, the Ministry of Agriculture, Forestry and Fisheries commenced a post-genome project entitled "Green Technology Program to Improve Food Supply Capabilities" based on the results achieved in the previous rice genome-related research, and it is promoting elucidation of the functions of usable genes in plants and networks between genes, the creation of technologies to efficiently grow these usable breeds using the research results, and the production of pioneering model systems that will contribute to stable supply of foods.

Additionally, the ministry is promoting the speeding up of the isolation of useful genes of pigs, elucidation of their functions, and discovery of DNA markers that will be effective in improving cattle. Also, focusing its attention on insects, which are the most unused resource in the 21st century, the ministry is promoting R&D directly connected to the creation of new industries, such as the production of useful materials applying the results of insect studies like decoding the silkworm genome. It is also involved in research to implement functional agricultural products using genetically altered technology, toward the implementation and commercialization of genome research results.

Besides these projects, the ministry also continues to promote the establishment of a crop-rotating technology system for high productivity and the development of production technology of seedlings for aquaculture that are difficult to artificially produce. Since 2006, in order to achieve a new target in the food self-sufficiency ratio, the ministry is promoting the following: (1) development of domestic agricultural goods with unique characteristics in quality or processing compatibility, for domestically produced agricultural goods for processing and industry, where the competition with imports is fierce, and (2) development of breeding and growing technologies to innovatively improve the productivity or nutritious value of domestic feeds and technologies to produce stockbreeding goods such as high-quality meats using domestic feeds.

With the outbreak of various incidents that threaten food safety and the enactment of the Basic Act on Nutritional Education, people are highly concerned with nutrition, and the guarantee of trusted and safe food products has become an important issue to be addressed. In order to expand and enhance food safety measures and to improve technology required to regulate food sanitation, with regard to additives, pollutants, chemical substances, residual pesticides, microorganisms, Bovine Spongiform Encephalopathy (BSE), health products, and food products derived from modern biotechnology, the Ministry of Health, Labour and Welfare has been promoting research on new factors that may cause damage, investigative research to formulate standards, and research and development towards establishing an official method of examination, while reflecting the achievements in risk control measures. Furthermore, the ministry has also conducted research on health risk control including countermeasures against food poisoning and food terrorism.

Additionally, the Ministry of Agriculture, Forestry and Fisheries is also trying to elucidate the properties of prion proteins to control Bovine Spongiform Encephalopathy (mad-cow disease, or BSE) and to diagnose it; to develop basic technology to diagnose and prevent infectious diseases common to man and animals, which will help eliminate people's fear and reduce impact on the stockbreeding industry if and when such a disease ever breaks out; and to develop technologies to produce stockbreeding products safely and securely for the purpose of reducing the use of antibiotics. Furthermore, since 2006, the ministry has been involved in improving the technology to detect and reduce toxic microbes; developing technology to prevent tampering with food labels; and developing methods of assessing the functionality of entire foods through means such as nutrigenomics.

(vi) Science and technology for the utilization of biological functions for the production of materials and improvement of the environment

The Ministry of Agriculture, Forestry and Fisheries has been involved in developing technology to reduce the use of chemical fertilizers and other agrichemicals by using organism functions and, since 2006, methods for assessing characteristics of soil organisms using eDNA (environmental DNA).

METI is developing technology to produce highly functional proteins with high add-on value, etc. in closed systems; analyzing the paths and functions by which plants produce substances; and developing other technologies such as bio-refinery technology, in projects supported by the New Energy and Industrial Technology Development Organization. The Ministry is also developing raw-decomposing and processing technologies for wastes and pollutants.

(4) Challenges in the upgrading of institutional infrastructure

(vii) Upgrading of life sciences infrastructure with the highest international standards

a) Preparation of bioresources

The field of bioresources is not limited to the mere preservation of genetic resources, but also plays an important role in exploring new areas of research. The national interest is served in the development, collection, storage, and provision of bioresources.

In Fiscal 2002, the Ministry of Education, Culture, Sports, Science and Technology instituted the "National BioResource Project" for the purpose of establishing a system facilitating the systematic collection, storage, and provision of bioresources that are of particular strategic importance to the nation, such as experimental animals and plants (such as mouse clones), various cells, and genetic data from various life forms.

Through the National Institute of Technology and Evaluation, which is a central agency for biogenetic resources (particularly of microbes) in Japan, METI is not only doing search, collection, and preservation of these biogenetic resources but is also organizing information concerning the resources (placing them systematically, information on base sequences, information concerning genes, etc.), providing services for R&D and commercialization.

The ministry is also actively involved in coordinating biogenetic resources in Asia through various means such as signing a bilateral agreement with another Asian country based on the Convention on Biological Diversity and founding a multi-national cooperative body (Asian Consortium) toward the preservation of microbe resources and their continuously maintained use. For unknown microbes such as those difficult to cultivate, through the New Energy and Industrial Technology Development Organization, the Ministry is developing technologies for collecting and preserving them; collecting biogenetic resources and analyzing their functions for these microbes; and building a biogenetic resources library based on genome information.

b) Promotion of bioinformatics

Recent advances in life science research have produced a massive amount of information like DNA base sequence data, 3D-structure data of proteins, and data concerning the emerging of genes. As a means to use databases containing these data effectively, it is critical to promote bioinformatics, a field created by fusing comprehensive database organization of life information together with life science and IT (information technology).

In 2006, MEXT began the "Integrated Database Project" to improve the usability of life-science relational databases of Japan, encouraging the integration of life-science relational databases. In the Ministry of Education, Culture, Sports, Science and Technology, the Institute for Bioinformatics Research and Development (BIRD) at the Japan Science and Technology Agency is actively engaged in the upgrading, standardization, and expansion of databases, as well as in the development of genome analysis tools. The ministry is also promoting the development of life science databases, including the DNA Data Bank of Japan (DDBJ), one of the three largest databases of its kind in the world, under the operation of the National Institute.

The Ministry of Health, Labour, and Welfare collects and preserves human and animal-derived cultured cells and genes needed for use in research in medical and pharmaceutical fields. The ministry also collects and preserves medical plants and provides them for researchers, while breeding and supplying crab-eating macaques and other animals used for medical testing. Additionally, in 2007, the ministry plans to start "bio-resources research" to enhance bio-resources related to diseases, etc.

The Ministry of Agriculture, Forestry and Fisheries is collecting, preserving, and providing biogenetic resources related to agriculture, forestry, and fisheries as a gene bank project; the ministry is also organizing, preserving, and providing rice genome resources.

In addition, since 2006, the ministry has been involved in organizing a database integrating various information and building a high-accuracy information search system by linking with other biogenetic information so that it may provide information on genome and genes of rice, silkworms, pigs, and other organisms related to agriculture, forestry, and fisheries to researchers in colleges, universities, and private industries (cf. Part 3, Chapter 3, Section 3-2).

METI is building and renewing useful and comprehensive databases of human genes, which includes the various annotations of gene function and relation with disease etc., and is developing software for automatic, extraction and prediction corresponding to the internationally rapid increase of the information on human genes.

(5) Miscellaneous

The "Human Frontier Science Program" (HFSP) operates based on the principles of "internationality," "interdisciplinary," and "encouragement of young scientists," to provide subsidies within an international framework for research that contributes to the elucidation of brain functions and other complex mechanisms of living organisms (cf. Part 3, Chapter 3, Section 4-1 (4)).

(Measures for appropriate ways to conduct animal experiments)

In June 2005, the "Act on Welfare and Management of Animals" was revised as a representative-originated law, and its Article 41 clarified the concept of 3R[2] concerning animal experiments.

The Animal Protection Law distinguishes experimental animals and animal experiments; for experimental animals, the Minister of Environment is to determine the standards, which was disclosed as a notice on April 28, 2006 as "Standards concerning the keeping and preserving of experimental animals and reducing their pain and suffering". MEXT, the Ministry of Health, Labour and Welfare, and the Ministry of Agriculture, Forestry and Fisheries established integrated basic policies for research institutions, etc. under their jurisdictions, promoting appropriate ways to conduct animal experiments based on these guidelines. The Science Council of Japan published its policy in the "Guidelines for Proper Conduct of Animal Experiments" on June 1, 2006.

(Efforts for bioethical issues)

Rapid development in the life sciences has raised expectations on innovation in medicine and other fields, but may also have brought about new bioethical problems with respect to human dignity and rights. In order to cope with these issues appropriately, the Expert Panel on Bioethics, established under the Council for Science and Technology Policy (CSTP), has been engaged in surveys and examinations of fundamental issues concerning bioethics, while MEXT, MHLW and other ministries are in charge of relevant laws, regulations, and guidelines and conducting other activities concerned.

Regarding human cloning technology, MEXT has taken measures prohibiting the production of human clone individuals under the Act Concerning Regulation Relating to Human Cloning Techniques and Other Similar Techniques (Year 2000, Act No. 146) and prohibiting the creation and utilization of human somatic cell nuclear transfer embryo (SCNT) for the time being under the guidelines based on the act.

In July 2004, the Council for Science and Technology Policy issued the statement on how to handle human fertilized embryos and human SCNT, entitled "Basic Policy concerning the Handling of Human Embryos" which is to regulate the creation and use of human fertilized embryos for research purposes and establish a framework to ensure the appropriateness of relevant research. In response to this statement, MEXT has been holding discussions by setting up the Working Group on the Utilization of human SCNT in the Expert Committee on Research on Specified Embryos and Human Embryonic Stem (ES) Cells in the Bioethics and Biosafety Commission of the Council for Science and Technology, and they recently summarized their basic interim position in June 2006. Concerning the use of human fertilized embryos in research for assisted reproduction medicine, MEXT and MHLW are working together closely in collaborative discussion, jointly organizing committees of the Expert Committee on Research on Assisted Reproductive Technology in the Bioethics and Biosafety Commission of the Council for Science and Technology of MEXT, and the special committee concerning human embryo research of MHLW.

In the area of human Embryonic Stem (ES) cell[3] research, MEXT has authorized research plans under the guidelines formulated in 2001. To date MEXT has confirmed the conformity of one derivation plan and 42 utilization plans (including three plans that have already completed) as of the end of January 2007.

Elsewhere, in the areas of human genome and gene sequencing research, epidemiological research[4], and clinical research, MEXT, MHLW and METI are cooperating with each other for the promotion of that

[2] 3R: Refinement (to cause as little pain to the animals as possible within the necessary limitations for scientific purposes), Replacement (to try to use whatever can replace the animals as much as possible within the scope in which the scientific purposes can be achieved), and Reduction (to use as few animals as possible within the scope in which the scientific purposes can be achieved).

[3] Human ES cell: Because this type of cell has the potential to split into every part of the human body, its applications to medicine are highly anticipated. On the other hand, there are ethical issues because these cells are obtained by destroying fertilized human eggs.

[4] Epidemiological (immunological) research: Scientific research in which frequencies and distributions concerning health-related events, such as diseases and infections, are studied to identify their causes.

research based on the guidelines[5] in order to ensure respect for human dignity and appropriate management of personal information.

(Efforts to ensure safety in the life sciences)

Recombinant DNA technology is applied to a broad range of fields, from basic biological research to the production of pharmaceuticals and improvement of agricultural crops, however, it also has characteristics to add new properties to living organisms. For this reason, the appropriate use of living modified organisms, etc. has been ensued based on the Act Concerning the Conservation and Sustainable Use of Biological Diversity through Regulations on the Use of Living Modified Organisms (Year 2003, Act No. 97), which stipulates the measures necessary to prevent adverse effects on biodiversity due to the utilization of living modified organisms. Written warnings or briefing sessions have been conducted on some organizations that illegally utilized living modified organisms after the Act was enforced, with an aim to ensure thorough compliance with laws and ordinances.

For clinical research aimed at the establishment of gene therapy[6], MEXT and MHLW are making efforts for the appropriate promotion of research based on the Guidelines for Gene Therapy Clinical Research, jointly formulated by the two ministries.

Tissues, cells, and other bio-materials originated in humans, as well as their information, are indispensable to medical research and life sciences, but there are a wide variety of ethical, legal, and social problems at each step-collection, preservation, processing, and utilization-of samples. Therefore, the Science Council of Japan has set up the "Committee on Bio-ethics Concerning Research Using Human-Originated Samples and Information" to discuss these issues.

The major life science research projects implemented in Fiscal 2006 are shown in Table 3-2-1, sorted by ministry or agency.

[5] Guidelines: ethical guidelines concerning human genome and gene-analysis research, ethical guidelines concerning epidemiological (immunological) research, ethical guidelines concerning clinical research, and guidelines concerning clinical research using human stem cells

[6] Gene therapy (genetic treatment): the method of treating a disease by injecting into the human body genes or gene-induced cells; currently this is not an established method of treatment; it is used as a part of clinical research.

Table 3-2-1 Major research subjects in life sciences (FY2006)

Ministry or agency	Research institute or program	Subject
Ministry of Finance	National Research Institute of Brewing	・Research and development in the manufacturing process for alcoholic beverages ・Research into alcoholic beverages ・Research into brewing-related microorganisms
Ministry of Education, Culture, Sports, Science and Technology	RIKEN (The Institute of Physical and Chemical Research)	・Promotion of bioresource projects ・Promotion of comprehensive research into brain science ・Promotion of comprehensive research into genome science ・Promotion of plant science research ・Promotion of comprehensive research into developmental and regenerative science ・Promotion of genetic polymorphism research ・Promotion of immunological and allergy research
	Japan Science and Technology Agency	・Promotion of bioinformatics ・Promotion of research using competitive funding
	National Institute of Radiological Sciences	・Promotion of research and development for upgrading heavy ion cancer therapy
	Japan Agency for Marine-Earth Science and Technology	・Research in oceanography, life in extreme environments
	Japan Aerospace Exploration Agency	・Research into medical science, etc., related to space
	Universities and colleges	・Comprehensive research in cancer science to conquer cancer ・Abnormality in genetic information system and emergence of cancer ・Destruction of cells and systems in cancer ・Immunological, chemical prevention and diagnosis of cancer ・Systematic cancer treatment based on basic research ・Elucidation of life systems using genome function analyses and informatics ・Genome-based elucidation of evolution and diversification by comparative genome analysis ・New development in medicine and bacteriology based on genome information ・Comprehensive basic structure to promote genome research toward a systematic understanding of life ・Comprehensive research on the functions of the brain ・High-degree function systems of the brain ・Elucidation of the functions of nerve circuits of the brain ・Elucidation of the mechanism of the brain function structure on the molecular level ・Elucidation of brain diseases ・Research on emerging and re-emerging infectious diseases
	HFSP (Human Frontier Science Program) (Note)	・International joint research for the elucidation of the complex mechanisms of living organisms

Ministry or agency	Research institute or program	Subject
Ministry of Health, Labour and Welfare	Health and labour sciences research grants	・Third term comprehensive control research for cancer ・Comprehensive research on aging and health ・Research on human genome, tissue engineering ・Research on psychiatric and neurological diseases and mental health ・Research on emerging and re-emerging infectious diseases ・Research on HIV/AIDS ・Research on sensory and communicative disorders ・Research for the eradication of intractable diseases ・Research into assuring and promoting reliability and safety of food ・Research on publicly essential drugs and medical devices ・Research on allergic disease and immunology ・Research on proteomics ・Research on toxicogenomics ・Research on analysis, support, and alternative medical devices for physical functioning ・Research on promotion of clinical application of translational research results ・Research on Clinical Trials' Infrastructure Development
	National Institute of Infectious Disease	・Research into gene recombinant vaccines, etc. ・Research into the development of vectors related to gene treatment, safety evaluations, etc. ・Research into AIDS, Hansen's disease, etc. ・Research into methods for the diagnosis, prevention, and treatment of SARS and other infectious diseases
	National Institute of Health Sciences	・Research into standard test methods, quality evaluation methods, etc. for pharmaceuticals ・Research into assuring the safety of food, chemical substances, living environment, etc. ・Research into safety information on drugs, food, chemical substances, etc.
	National Institute of Occupational Safety and Health	・Research on prevention of fatigue accumulation by overwork ・Research on occupational hazard of asbestos and its risk ・Research on the functionality and comfort when wearing labor hygiene protective gear
Ministry of Agriculture, Forestry and Fisheries	National Agriculture and Food Research Organization, National Institute of Agrobiological Sciences, etc.	・Breeding and integrated research toward enhancing consumption of domestic farm products in food service industry ・Integrated research for developing Japanese-style forage feeding system to increase forage self-support ratio ・Development of technology for reducing the impact on the environment using biofunction ・Development of technologies for the suppression of Bovine Spongiform Encephalopathy (BSE), and diseases shared by humans and animals ・Development of safe and secure manufacturing technologies for animal products ・Development of the seed production technology in the Japanese eel and spiny lobster ・Development of technology to analyze the characteristics of soil organisms by understanding of soil microflora ・Development of efficient technology for breeding specific kinds by genome breeding ・Research on plant (rice) and animal genome for useful applications of genetics ・Insect Technology Research for Utilization of the Greatest Unused Resources of the 21st Century

Ministry or agency	Research institute or program	Subject
		・Comprehensive research into food safety and functionality ・Assurance of Safe Use of Genetically Modified Organisms ・Development of evaluation and management techniques for supplies of safe, reliable, and highly functional foods and agricultural goods ・Development of technology for establishing a regional crop-rotation system for high productivity ・Gene bank project ・Creation of an integrated database of genome information on agricultural, forestry, and fisheries products
	Private sector, universities, etc.	・Research on the implementation and commercialization of agri-bio technology
Ministry of Economy, Trade and Industry	New Energy and Industrial Technology Development Organization	・Development of basic bio-technology to support faster creation of genome-based medicines ・Development of basic technology for creating anti-body medicines with new functions ・Development of technology to apply sugar-chain functions ・Development project to implement bio-processes ・Development of basic technology for environmentally harmonious manufacturing using the functions of microbes ・Developing basic technology for high-quality manufacturing using plant functions ・Developing new diagnostic technology through fusion with nanotechnology toward implementation of individualized medical practice ・Development of an integrated database for human genes ・Informatics that detects functional RNA from genome; development of techniques and tools to analyze it; analysis of its functions ・Development of technologies for the analysis of intracellular network dynamism
	National Institute of Advanced Industrial Science and Technology	・Development of bio-markers using sugar chains ・Development of material-production technology using functions of living organisms ・Development of medical and welfare devices based on ergonomics
	HFSP (Human Frontier Science Program) (Note)	・International joint research for the elucidation of the complex mechanisms of living organisms

Note: Funding provided by the Ministry of Education, Culture, Sports, Science and Technology, and the Ministry of Economy, Trade and Industry.

3.2.2.2 Information and Communications

Information and communications technology are changing a wide range of socio-economic activities in a revolutionary way, not just in the industry but also in our daily lives, through means such as the implementation and widespread use of electronic government, working at home, remote medical practice, and distance education. This technology is becoming a critical foundation for the people to live in a safe and secure way. Further, mid- to long-range investment with emphases on those information and communications technologies in which Japan is leading internationally will lead to enhancement in science and technology, academic research, and the industrial competitiveness of Japan.

The government's involvement in the general field of information and communications is spelled out in the "New IT Reform Strategy" (January 2006) and "Priority Policy Program 2006" (July 2006) at the Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society (IT Strategic Headquarters). The goal is to "achieve a society where the benefits of IT can be felt whenever, wherever, and whoever you are."

The Ministry of Internal Affairs and Communications (MIC) plans to promote research and development in an intensive and strategic manner, based on the "UNS strategy programs" (responses in the Telecommunications Council, July 2005), which specifies the directions of R&D to be emphatically promoted as well as the "Field-by-Field Promotion Strategy," and other guidelines.

Under the "Field-by-Field Promotion Strategy" in the

field of information and communications, MEXT prepared a document in July 2006 at the Subdivision on R&D Planning and Evaluation in the Council for Science and Technology; the document is the "Promotion guidelines for research and development concerning information science and technology," which summarizes research and development to be carried out with emphasis.

Below, major guidelines for each ministry and agency are summarized under the seven "critical research and development topics" in the "Field-by-Field Promotion Strategy."

(1) Network domain

In order to construct next-generation network technology which enables us to communicate a massive amount of information instantly and which anyone can use comfortably and conveniently, MIC is carrying out a variety of research projects including the following: research and development of basic technology necessary for the construction of an all-packet-type, highly functional network; research and development to address the explosive increase in Internet traffic and to strengthen the information-communication infrastructure; all-optical networks that can stably control, with extremely low power consumption, communication traffic which will have increased even more in 10 years; advanced technologies for sharing the use of radio waves through multiple radio systems; and research and development related to technologies that will make it easy to construct wireless systems in unused frequency bands.

(2) Ubiquitous network (RFID tag) domain

MIC, with the goal of achieving a ubiquitous network society in which access is available "anytime, anywhere, for anything, by anyone" is working on developing the technology which will, using many terminals (RFID tags, sensors, information household appliances, etc.), connect people to people, people to things, and things to things with information so that networks can be used conveniently and safely. For example, the project "R&D on Basic ubiquitous network (the ability to access anything from anywhere) technologies," research and development are under way for necessary basic technologies such as "microscopic chip networking technology," "ubiquitous networking authentication and agent technology," and "ubiquitous networking control and management technology."

Observing the reality of the ubiquitous society, MEXT is promoting research and development projects that will establish basic technologies necessary for us to use information with high add-on value safely and instantly through RFID tags.

METI is promoting international standardization of related standards for RFID tags and has developed technology concerning price-reduction (5 yen per unit, assuming 100 million units produced monthly).

The Ministry of Land, Infrastructure and Transport, in its "Free Mobility Project," carried out experimental operation of a ubiquitous location information system using RFID tags developed under the project "microscopic chip networking technology" of MIC.

The Cabinet Office is promoting collaboration with ministries according to the above guidelines, centered on the RFID tag technology, as a group of science and technology collaboration guidelines. It is also promoting, through Special Coordination Funds for Promoting Science and Technology, their use in the medical field and the complementary challenge involving measurement and safety/security.

(3) Device/display domain

METI has developed various technologies. In semiconductor technology, it has developed the miniaturization technology at a 45-nanometer level of technology, which can create next-generation high-performance semiconductors with low power consumption (processing and material technology, exposed system technology, design technology, masking technology, etc.). It has also developed application chip technologies that can lead to reduced power consumption of information household appliances (including those installed in automobiles). In display, memory-storage, and network device technologies, the ministry has carried out research and development of display/light-emitting devices using high-efficient organic materials, high-capacity, high-speed storage technology with low power consumption using an innovative principle, and high-efficient network device technology using electronic and optical technology.

(4) Security and software domain

MIC has carried out fundamental examination of the detection, mitigating and prevention of BGP prefix hijacking, research and development of technologies for advanced network authentication technology, and so on.

In the field of information household appliances, METI

is involved in the development of voice-recognition technology with real world applications. The ministry is also involved in research and trial of a method for efficiently developing highly reliable installed software, etc. Further, the ministry has created an environment in which open-source software (OSS) can be used safely.

MIC and METI are carrying out development and trial operation of a bot trapping / analyzing system. In addition, they are carrying out the development of technology for preventing damage caused by new types of threats to information security, and technology for minimizing the damage in the case where any has occurred. Further, they are carrying out research for ensuring information security, which is deeply involved with the people's lives and socioeconomic activities, and research on management techniques for developing an environment that enables people to use IT with a sense of security.

(5) Human interfaces and contents domain

MIC has created a first prototype of a multi-language communication system mainly for travel conversation, under the project "realization of super communication among numerous countries." Also, under "the project for realization of enhanced human interfaces," fundamental exploration is carried out foundational discussions to analyze the information processing inside the brain. Under "technology to create heart-moving contents and information applications to be shared with the world," the ministry is doing research and development in the technologies that will support the production and distribution of next-generation-type image contents. In 2006, the element technology established in the previous fiscal year was extended, validating that it is possible to transmit 4K images created by synthesizing 2K images collected from 4 remote locations and digital video from a 4K camera, to 10 locations including remote locations.

(6) Robot domain

MIC is involved in research and development toward creating robots that can provide services like life support and welfare/caretaking support; this is done by linking various types of robots with versatile sensors and devices via a network to further improve the single-function robot.

METI is creating validating units for the purpose of developing safety technologies and ways to assure safety, as well as for developing technologies for implementation, to actually introduce and operate service robots such as cleaning robots and transporting robots. Further, the ministry is carrying out development, with realistic uses in mind, in the fields of next-generation industrial robots, service robots, and special environmental work robots.

Under the above-mentioned guidelines, the Cabinet Office of Japan is promoting one of the Coordination Programs for Science and Technology as "Next-Generation Robots -establishment of common platform technology-," conducting some projects such as the Structuring Environmental Information Project funded by the Special Coordination Funds for Promoting Science and Technology. Additionally, the Cabinet Office holds the joint symposium "Robot Creation Education" with MEXT, verifying the educational value of robot creation and its meaningfulness in science education and technical education.

(7) Research and development basic domain

As a Key Technology of National Importance ("The world's highest level next generation super computer that carries science and technology forward," Strategic Prioritized S&T), MEXT is promoting the project "development and use of state-of-the-art, high-performance general-purpose supercomputer" so that Japan maintain world-leading positions in a wide range of areas such as science and technology, academic research, industry and medicine.

(8) Miscellaneous

As science and technology projects with a strategic emphasis, MEXT is promoting programs such as the "Leading IT Specialist Training Promotion Program," toward the formation of a central location where a graduate school can train human resources who will, as IT personnel with the highest standard in the world, address the changes in social circumstances with flexibility and foresight and play leading roles in companies and other organizations.

Main research topics in the field of information and communications in 2006 are shown in Table 3-2-2.

Table 3-2-2 Major research subjects in the information and communications sector (FY2006)

Ministry or agency	Research institute or program	Subject
Ministry of Internal Affairs and Communications		・Research and development concerning next-generation backbones ・Research and development on ultra functional network technologies utilizing nanotechnology ・Research and development on element technology toward high-level uses of frequencies in mobile communication systems ・Research and development on basic technologies toward promoting a transition of wireless systems to unused frequency bands ・Research and development on ubiquitous sensor network technology ・Research and development for Sophisticated Use of RFID ・Research and development on Asia's ubiquitous platform technologies ・Research and development on ubiquitous network technologies ・Research and development on technologies for high-level usage of information household appliances ・A trial to stop Cyber Attacks, such as spam, phishing ・Research and development on detection, recovery, and prevention of path hijacking ・Research and development concerning basic technologies for high-level network authentication ・Research and development on the next-generation-type of image contents production and distribution support technology ・Comprehensive research and development into network human interface technologies
	National Institute of Information and Communications Technology (NICT)	・Research and development on basic technologies for next-generation networks ・Research and development on photonic network technologies
Ministry of Education, Culture, Sports, Science and Technology		・Development and use of state-of-the-art high-performance general-purpose supercomputer ・Leading IT specialist training promotion program ・Research and development project of elemental technology for super computing of the future ・Research and development project for innovative simulation software ・Research and development project of fundamental technology for supporting a safe ubiquitous society
Ministry of Agriculture, Forestry and Fisheries		・Development of technologies for robot-harvesting fruits and vegetables
Ministry of Economy, Trade and Industry		・Contract expenses for studies to develop an electronic tag system with efficient energy use ("Hibiki" project) ・(1) Actual implementation of industry-academia collaborative software engineering, listed under the coordination of industry-academia collaborative software engineering center ・Task of developing software that builds the basis of a leading society ・Task of supporting the creation of a service robot market ・Developing technologies using information household appliance sensors and human interface devices
	New Energy and Industrial Technology Development Organization (NEDO)	・MIRAI project ・Developing comprehensive optimization technologies for masking design, drawing, and inspecting ・Development of an Extreme Ultraviolet (EUV) exposure system ・Developing technologies for next-generation process-friendly designing ・Semiconductor application chip project ・Developing superconducting network devices with low power consumption ・Developing large-capacity optical storage technology ・Development of photonic network technology, etc. ・Development of efficient organic device technology ・Project to develop element technologies for strategic, cutting-edge robots
	Information Technology Promotion Agency (IPA)	・Task of creating an early warning system for computer security ・Taking security measures for corporate and private information ・(2) central location for industry-academia collaborative software engineering, listed under the coordination of industry-academia collaborative software engineering center ・Creating the basis of open-source software applications
Ministry of Land, Infrastructure and Transport		・Autonomous moving support project ・Developing IT execution systems via robots, etc. ・Research concerning work and monitoring by robots in the ocean

3.2.2.3 Environment

The field of the environment is an essential area of science for the preservation of the natural environment, including ecological systems with their diverse forms of life, for the maintenance of human health and the preservation of the living environment, and for maintaining the foundations for the future survival of mankind. At present, there is an increasing need for efforts in science and technology to resolve global environmental problems, and the Third Science and Technology Basic Plan places priority on the field of the environment. Japan has divided the field into six research areas to conduct the measures detailed below.

(1) Research area related to climate change

(Observation of tropospherical changes due to small amount of greenhouse gas and other causes)

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) is implementing observational studies and technology development in order to establish a system to observe changes in atmospheric composition of minor components included in the atmosphere (nitrogen dioxide, ozone, etc.) and aerosol in the troposphere, about which there are uncertainties regarding environment preservation measures and climate prediction in the future.

(Resolving the response process in continental areas and ocean that is related to climate change)

MEXT is developing advanced observational equipment for carbon dioxide in the marine surface layer, ocean water and the atmosphere (low-priced unmanned observational equipment of small size and high durability, or simple and highly precise automatic measuring equipment that can be introduced in a large number of ships), in order to resolve the circulation mechanism of greenhouse effect substances including carbon dioxide in the ocean and other places, and make future predictions thereof. The Ministry is also verifying the precision of observational equipment and enhancing the observation network.

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is promoting research on global environment prediction, including climate variation research. As strategically focused science and technology, the Agency is implementing fundamental study aimed at resolving the mechanism of global environmental changes and the prediction thereof.

Japanese Antarctic Research Programs are centered at the National Institute of Polar Research, affiliated to the Headquarters for the Japanese Antarctic Research Expedition (JARE) (Chairman: Minister of MEXT), and are operated in cooperation with relevant government agencies. In Fiscal 2006, the 47th winter expedition and the 48th expedition carried out routine observations of ocean and atmospheric phenomena around Showa Station, and also performed monitoring observations, etc., for the purpose of bringing to light environmental changes on a global scale. In particular, following the previous year, it succeeded in sampling rock particles that are considered to originate from the ice core and bedrock up to 3,035.22m deep, at Dome Fuji Station. Also, observation of ambient aerosol using aircraft was conducted jointly with a German research expedition near Showa Station.

The Ministry of Agriculture, Forestry and Fisheries (MAFF) has been working on the development of a carbon cycling model for forest and farmland that is conducive to the promotion of countermeasures against global warming from Fiscal 2006.

(Climate change projection in the 21st century using climate model)

As strategically focused science and technology, MEXT promoted the implementation of global warming/climate change prediction experiments and the development of climate models by using "Earth Simulator," one of the world's most powerful supercomputers, possessed by Japan, under the "Project for Sustainable Coexistence of Humans, Nature and the Earth." Through this, development of unprecedented high-resolution models and the variations of models through experimental reproduction of climate were achieved. Also, various prediction experiments based on the greenhouse gas increase scenario by the Intergovernmental Panel on Climate Change (IPCC) were conducted, contributing in the preparation of the Fourth Assessment Report by IPCC, to be published in 2007, in terms of the prediction of changes in ocean circulation and precipitation phenomena (including seasonal rain fronts and typhoons) due to global warming. Furthermore, in order to adequately cope with issues such as climate change, water resource management, agriculture and other social problems that human society is currently facing, MEXT is promoting the establishment of the "Data

Integration and Analysis System (DIAS)," aimed to integrate and analyze various data obtained by satellite, numerical model and *in-situ* observations to create and provide useful information for policy makers and researchers.

In addition, the Ministry promotes stable and efficient operation of the "Earth Simulator" by JAMSTEC. At the same time, it implements research and development for technology to improve the precision and speed of simulation using the "Earth Simulator" and technology to predict global environmental changes using the simulation, as strategically focused science and technology.

(Monitoring of greenhouse gas and supracrustal environment using satellites)

Observation of greenhouse gas and supracrustal environment using satellites is being promoted as strategically focused science and technology. Because Earth observation by satellite is a highly effective means for observation that can collect various kinds of information extensively in a repeated and continuous manner, it is being promoted comprehensively under cooperation with related entities in and outside Japan, with the aim of solving environmental problems.

The Ministry of the Environment (MOE) is working jointly with the Japan Aerospace Exploration Agency (JAXA) and the National Institute for Environmental Studies on the development of a greenhouse gas observation sensor to be equipped on the Greenhouse Gases Observing Satellite (GOSAT).

JAXA processes the data collected from a Precipitation Radar (PR) mounted on the Tropical Rainfall Measuring Mission (TRMM) satellite of the National Aeronautics and Space Administration (NASA) of the US and other satellites to provide the data for researchers and users. JAXA launched the Advanced Land Observing Satellite "DAICHI" (ALOS) in January 2006 and began routine operation of the satellite in October. JAXA is also developing, in cooperation with relevant agencies, the Greenhouse Gases Observing Satellite (GOSAT), the Global Precipitation Measurement/Dual-frequency Precipitation Radar (GPM/DPR), and the Global Change Observation Mission (GCOM).

(R&D and related measures for understanding phenomena on a global scale)

The Ministry of Internal Affairs and Communications (MIC) started research and development on sensing network technology for resolving three-dimensional structures of the urban atmosphere, which also has a large impact on environmental changes in Asia and in the entire world, through the National Institute of Information and Communications Technology from Fiscal 2006.

MOE is promoting research studies conducive to preservation of the global environment, such as research on the destruction of the ozone layer and global warming, as well as observation necessary for countermeasures against global warming, from mid- and long-term perspectives.

(Earth Observation Technology Using Satellites)

The National Institute of Information and Communications Technology (NICT), governed by the Ministry of Internal Affairs and Communications, is promoting the development of a Superconducting Submillimeter Wave Limb Emission Sounder (SMILES)[7] mounted on the exposed facility of the Japanese Experiment Module (JEM; also known as "Kibo") on the International Space Station. NICT is also studying technology to enable the measurement of global environmental changes from space.

The Ministry of Agriculture, Forestry and Fisheries has created a database of imaging data obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS) mounted on Terra and Aqua NASA global observing satellites, and has made it available on the Internet.

(2) Research area related to hydrological cycles and solute transport in watersheds

MEXT is establishing an oceanic research and observation network under international cooperation (including an offshore moored buoy network for oceanic observation) and research and observation network using Doppler radar, in order to resolve the mechanism of hydrological cycle and climate change in the Asian

[7] Superconducting Submillimeter Wave Limb Emission Sounder: This points the antenna to the direction of the rim of the atmosphere, receives the submillimeter waves that are radiated from micro-molecules in the atmosphere with a supersensitive low noise receiver using a superconducting sensor, and measures the amount of ozone and other substances.

monsoon region. Through this effort, the Ministry is collecting observation data for atmospheric/oceanic fluctuation phenomena (including the Indian Ocean dipole mode phenomenon), and observational research thereof. In addition, as strategically focused science and technology, it is implementing research and development aimed for the prediction of water resources and water damages in the future under the "Project for Sustainable Coexistence of Humans, Nature and the Earth."

Global Earth observation systems to collect data on regional and global circulation systems of water, thermal and material have been established. At the same time, research and development to monitor climate change, water cycle ecosystems using satellite and *in-situ* observations are being promoted.

The Ministry of Internal Affairs and Communications developed a long range ocean radar, which realizes continuous long-term observation of the flow field of the Kuroshio Current, etc. at the shore at the National Institute of Information and Communications Technology. The Ministry has installed the radars at Ishigaki and Yonaguni Islands and is observing the flow field of the Kuroshio Current south of the East China Sea.

MAFF is engaged in the development of nature-friendly control technologies for the hydrological cycle, and for agricultural, forestry, and fishery ecologies in drainage basins, to encourage agriculture, forestry, and fisheries industries that co-exist with nature.

To observe the global ocean in real time, MEXT and the Ministry of Land, Infrastructure and Transport (MLIT) have been engaged in the development of an Advanced Ocean Observing System (ARGO[8]). In this project, 3,000 mid-depth floats are being deployed with international cooperation all around the world to measure temperature and salinity to an ocean depth of 2,000m.

MLIT is working on a variety of research, including research on the development of new geologic materials based on various wastes and their application in harbor facilities, development of strategic stock management methods for housings and social capital, development of technology to reduce and recycle construction wastes, formation of waste flow systems to facilitate cyclical usage of resources and research on the collection of biomass energy from sewage sludge and animal manure.

(3) Research area related to ecosystem management

The Ministry of the Environment is promoting research into the prediction of and countermeasures against the effects of a decrease in biodiversity, by using the Global Environment Research Fund. The ministry is promoting research into the design and presentation of scenarios for coexistence with nature in major cities and drainage basins, in relation to the "topic of technologies for the rejuvenation of drainage basins and major cities that are co-existent with nature" funded by the Environmental Technology Development Fund.

(4) Research area related to chemical risk and safety management

Chemical substances are used in various products, becoming more essential to people's lives. However, in order to sufficiently utilize their benefit, it is necessary to scientifically understand the risk and address it appropriately as well as to develop a society with a good sense of balancing risk and benefit. Survey, research and development as well as the formation of an intellectual foundation is currently being conducted mainly by relevant ministries for the development of risk evaluation/management methods for chemical substances, collection and provision of information on safety, as well as the development of testing/measurement methods necessary for them.

MAFF is working on resolving the dynamic state of the ecosystem in the area of agriculture, forestry and fisheries, development of evaluation methods for the impact on living organisms and ecosystems, and development of technology for dissolution and detoxification, for hazardous chemical substances.

The Ministry of Economy, Trade and Industry (METI) is promoting the establishment of methods and development of an intellectual foundation in order to comprehensively manage risk evaluation for the entire life cycle of chemical substances under the management program for the comprehensive evaluation of chemical substances, as well as the development of processes and methods conducive to reducing the risk of hazardous chemical substances. The Ministry is also promoting the development of technology related to the reduction and restraint of substances affecting the environment that is generated from industrial activities.

MOE is promoting the research and development of methods for risk assessment test and measurement methods for chemical substances including the development of an intellectual foundation in order to contribute to countermeasures against environmental risks of chemical substances. In Fiscal 2006, MOE started surveys and research for related information and possible

[8] ARGO is named after the ship of the Greek mythic hero Jason, which is the name of the related earth observation satellites series.

countermeasures on hazardous metal.

(5) Research area related 3R[9] technologies

Not only the development of technology in downstream sectors such as the recycling of wastes but also METI is promoting the development of 3R-conscious technology in upstream sectors such as the expansion of product life and designing/manufacturing of products easy to recycle.

MOE is working on solving various problems related to wastes and promoting a variety of research conducive to building a material-cycle society, including research on international 3R such as in the Asian region, aiming to contribute in the establishment of international 3R, social-scientific research for building a material-cycle society, research on safe and assuring waste treatment technology including the solution for the asbestos problem, and research on evaluation methods for efficient and effective implementation of measures related to waste treatment businesses.

(6) Research area related to the biomass utilization technologies

As strategically focused science and technology, MEXT is developing processing technology for detoxification disposal or recycling of wastes and biomass. At the same time, the Ministry is implementing research and development on impact/safety assessment and social system design under a link-up between industry, academia, and government.

MAFF is promoting the development of recycling and utilization technologies for biomass, the development of system technologies for the efficient recycling and utilization of local biomass resources, and the development of new energy production technologies that utilize organic resources in place of fossil fuels. In addition, the Ministry is developing technologies to reduce production costs for biomass plastic. Furthermore, the Ministry is engaged in the development of technologies for the sorting and transport of recycled foodstuffs, an area that has long been a bottleneck, preventing the promotion of foodstuff recycling, as well as the development of reproduction and conversion technologies, and of constituent and quality evaluation technologies, needed for the promotion of advanced uses.

In Fiscal 2004, MOE started promoting development for the practical application of basic global warming countermeasure technology, such as the manufacturing of bioethanol in Miyakojima, Okinawa and the demonstration of gasoline containing 3% of bioethanol, as well as the development of global warming countermeasure technology that can be commercialized in a short period of time.

(7) Other

MLIT is promoting the development of drainage basin restoration and recovery technologies that take the entire drainage basin into account for comprehensive hydrologic cycle management, as well as the development of land and infrastructure technologies offering co-existence with nature.

Funded by the Global Environment Research Fund and Survey and Research Funds for Global Environment Preservation, MOE is implementing research on material cycling mechanism and oceanic pollution due to hazardous chemical substances, in order to contribute in the preservation of the global marine environment.

Major research subjects conducted during Fiscal 2006 are as shown in Table 3-2-3.

[9] 3R: Reduce, Reuse, Recycle

Table 3-2-3 Major research topics for the environment sector (FY2006)

Ministry or agency	Research institute	Research topics
Ministry of Internal Affairs and Communications	National Institute of Information and Communications Technology	・Research on measurement technology for global environmental changes ・Research and development of technologies for the measurement of subtropical Earth environments ・Research on global environment measurement and forecasting technology, using 3-D high-resolution imaging radar ・Research on sensing network technology ・Promotion of international information networks for conservation of the Earth's environment
	Fire and Disaster Management Agency	・Ensuring security corresponding to the utilization of new technology/materials
Ministry of Education, Culture, Sports, Science and Technology	Japan Agency for Marine-Earth Science and Technology, Japan Aerospace Exploration Agency, National Institute for Environmental Studies, universities, etc.	・Earth Observation and Ocean Exploration System ・Research on global environment observation ・Research on the prediction of global environmental changes ・Project for Sustainable Coexistence of Humans, Nature and the Earth ・Plan for promoting the establishment of global observation system ・Project for composite treatment and recycling of general/industrial waste and biomass
Ministry of Agriculture, Forestry and Fisheries	National Agriculture and Food Research Organization, Forestry and Forest Products Research Institute, etc.	・Development of new technology for the treatment and local recycling of biomass ・Assessment and mitigation techniques of global warming effects on the agriculture, forestry and fisheries sector ・Development of symbiotic management technology of water circulation/agricultural, forestry and fisheries ecosystem in the basin zone ・Development of comprehensive management system of hazardous chemicals in agricultural, forestry and fisheries ecosystems ・Assessment of the impact of global-scale change in water cycles on food production and alternative policy scenarios
	National Agriculture and Food Research Organization, etc.	・Development of technology for reducing the production cost of biomass plastics
Ministry of Economy, Trade and Industry		・R&D on architectural structure with new structural system using innovative structural materials ・Technology development for life extension and high-level maintenance of architectural structure
	National Institute of Advanced Industrial Science and Technology	・Resolving the amount of the long-term absorption of carbon dioxide by the Pacific Ocean through data analysis of mid-deep seawater. ・Development of chemical substances and production technology using biomass as raw material ・Technology to produce ethanol from woody biomass
	New Energy and Industrial Technology Development Organization	・Regional biomass heat usage field test business ・Development of methods for brief assessment of the hazardous property of oil refinery substances, etc. ・Development of evaluation methods for the properties of nanoparticles ・Development of alternate technology for high-level lead soldering to promote the recycling of electric and electronic appliances ・Infrastructure development related to the promotion of environment-conscious designing ・Development of fundamental technology for the creation of environment-conscious ultrafine grain steel
Ministry of Land, Infrastructure and Transport	Engineering Affairs Division	・Development of housing and urban infrastructure management technology for sustainable society and safe environment ・Development of management technology for infrastructure and building stocks ・Development of evaluation method and technical measures of environmental impact throughout a building's life cycle ・Development of thermal environment evaluation and countermeasure technologies for urban space
	National Institute for Land and Infrastructure Management	・Research into supporting technology for energy conservation with better performance of existing residences ・Wetland restoration project for urban area ・Strategic planning and adaptive management on environment restoration in coastal zone ・Research initiative with respect to achieving a more healthy water cycle in consort with regional activities
	Public Works Research Institute	・Development of recycling construction technology for building a material-cycle society ・Development of the regional system for the cycling and usage of biomass, based on the joint biogas plant ・Development of dam technology to preserve the natural environment ・Development of technology to alleviate environmental risks in daily life ・Development of technology to preserve/restore water ecosystems ・Research on the intensive land use of coastal areas in cold regions ・Development of designing technology for river basins and channels that coexists with the environment in the field of rivers in cold regions
	Building Research Institute	・Quality management of structural recycled coarse aggregate from river sands and gravel as the original material, and study on blend and quality evaluation of concrete using the recycled coarse aggregate ・Development of technology to measure indoor air environment and ventilation methods for housing that are conducive to ensure health ・Development of technology to reduce environmental load by ensuring advanced sewage treatment for existing water-purifier tanks, and evaluation technology thereof
	National Maritime Research Institute	・Research conducive to the prevention of marine pollution due to emission and effluence of oil and hazardous liquid from ships ・Research conducive to the prevention of air pollution due to gas emission from ships
	Hydrographic and Oceanographic Department, Japan Coast Guard	・As part of activities of Hydrographic and Oceanographic department, geomorphological and geological surveys of sea bottoms for the detection of volcanic eruptions, and observations of water temperatures, ocean currents, waves, and other aspects of the Western Pacific ocean region

Ministry or agency	Research institute	Research topics
	Meteorological Research Institute, Meteorological Agency	・Comprehensive projection of climatic change around Japan due to global warming ・Development and improvement of a materials circulation model and research on assessment of the effect on the global environment ・Observational study of radiative process in the atmosphere
	Geographical Survey Institute	・Geodynamics by precise Earth measurement ・International cooperative study on plate motion and deformation in the East Asia and Pacific regions ・Technical development of precise determination of the geoid and the gravity field variations in the Northwest Pacific from dedicated satellite gravity dates ・Development of a correction model for seasonal variations observed in GPS coordinate time-series ・Geoecological research and survey using airborne LIDAR data – Case study in Shirakami Mountains –
	Port and Airport Research Institute	・Sea level rise monitoring by tidal level observation ・Research on the changes in the characteristics of the emergence of tidal waves due to global warming ・Research on recycling technology in coastal areas ・Research on the lifecycle management of harbor and airport facilities ・Research on the evaluation and countermeasures for the impact of hazardous chemical substances in coastal areas ・Research on countermeasure technology against oil spill in coastal areas ・Research on the comprehensive environment monitoring and environment prediction model in Tokyo Bay
	Civil Engineering Research Institute for Cold Region	・Regionally independent energy experimental study conducive to countermeasures for global warming
Ministry of Environment	Global Environment Research Fund	・Development of Greenhouse-gas Sink/Source Control Technologies through Conservation and Efficient Management of Terrestrial Ecosystems ・Research on Sustainable Land Management in Atoll Island Countries ・Impact Assessment of Future Climate Change Using High-Resolution Climate Change Scenarios Including Extreme Events ・Integrated Research on Carbon Budget Management in Terrestrial Ecosystems of Asia in the 21st Century ・Research on Explanation of Long-Term Trend and Prediction of Future Change of Ozone Layer ・Comprehensive assessment of climate change impacts to determine the dangerous level of global warming and to determine appropriate stabilization target of atmospheric GHG concentration ・Studies of Impact of Marine Organisms Introduced by the Ballast Water/ship Hull Community on Coastal Ecosystems and the Efficient Management of Ballast Waters ・Study on the Ecological Deterioration of East Asian Marginal Seas due to the Anthropogenic Change in Effluent Nutrient Ratio ・Impacts of invasive alien species on biodiversity and mitigation of fragile ecosystems in the oceanic Ogasawara (Bonin) Islands ・System construction of vulnerability assessment for alpine and subalpine ecosystems based on biological interactions ・The study for methods and measures of invasive alien species risk assessment ・Productivity, Clothing, Energy Conservation and Indoor Environment in 28°C Office
	Global Environment Research Coordination System	・Observation of greenhouse gas over Asia-Pacific region utilizing commercial aircrafts ・Study on environmental impacts on oceanic material cycling bypurposeful sequestration of CO2 in the ocean ・Observation of oxygen and isotope ratio of carbon dioxide in the background atmosphere for the detection of long-term change in CO2 sink of ocean and terrestrial ecosystem ・Study on distribution of trace greenhouse gases over the Western Pacific and their sources
	Environmental Technology Development Fund	・Research on the restoration of hydrological/material cycle that can coexist with nature and the development of ecosystem evaluation technology in urban and basin areas ・Research on the development of environmental assessment technology using technology for multielement and multicomponent simultaneous measuring for ambient nanoparticles ・Research on environmental risk evaluation method for compound soil contamination caused by mineral oil and others ・Research on the development of evaluation methods for the impact of chemical substances on the ecosystem based on genomics

Ministry or agency	Research institute	Research topics
Ministry of Environment	Environment Waste Management Research Grant	・Research on the technology system vision and diversion strategy in material-cycle society in the near future ・Research on waste/resource management strategy through the establishment of material stock account system and application thereof ・Development of material flow simulator for environmental load evaluation in concrete industry and the establishment of optimization supporting system ・Analysis of generation characteristics of hazardous substances in the disposal and recycling process of waste containing plastics and the development of efficient countermeasure methods ・Upgrade recycling of chlorine plastic products by substitutional dechlorination and the collection of valuable metal ・Persistent chemical substances in household products and 3R scenario analysis ・Lifecycle comparison methods of different scenarios including overseas recycling and application to discarded plastics ・Analysis of resource cycling system for discarded electric and electronic devices and discarded plastics in Asian region ・Research on policies related to the improvement of waste resources management ability in China －effectiveness of regional waste resource management and its diffusion into the regional society for the realization of regional cycling system － ・Research on the actual state of international health policy and medical waste as well as management thereof in Asia ・Research on the analysis of the actual state of extended producer responsibility system in Japan and South Korea and the establishment of partnership ・Actual state of recycling in Asia and management/3R policy for international resource cycle ・Comparative research of automobile recycle system in Asia ・Research on the possibility of producing charcoal dust fuel from waste biomass and method to remove hazardous substances from it ・Research on the refining of dehydrated ethanol by ultrasonic and the production of biodiesel fuel in terms of the utilization of biomass cycling system (cycling of CO2)
	Technology Development Business for Global Warming Countermeasures	・Technology development for the practical use of biomass ethanol production process through enzyme method ・Development of practical bioprocess to improve the energy acquisition rate in the production of ethanol, hydrogen and methane from herbaceous and woody biomasses ・Development of the production process of ethanol for fuel from molasses produced in Okinawa and demonstration experiment including E3 ・Development of technology to introduce gasoline containing bioethanol and demonstrating business ・Development of technology on the production of biomass ethanol from sugar cane for fuel production in Okinawa area ・Establishment of G hydrogen model society in Honjo and Waseda areas ・Regional Eco Energy Web System (development of technology related to the controlling method for mutual energy usage system, mainly for the natural energy) ・Technology development and demonstration business for Academic City East Hiroshima Model related to the introduction of urban biomass energy technology ・Practical use of on-site energy conversion system for urban organic waste by supercritical water ・Development of woody biomass utilization technology aimed for CO2-free society and the establishment of Yakushima Model for renewable energy fusing system
		・Development of technology to produce woody biocoke by Pyrocoking technology and system to apply to SOFC power generation ・Development of household and industrial charcoal dust combustion equipment for biomass charcoal dust network
	Research Funding for the National Research Institute engaged in Environmental Pollution Research	・Production cost of observational research equipment equipped on satellites
	Survey and Research Funds for the National Organization for Pollution Prevention	・Research on comprehensive management methods conducive to unified preservation of ocean and land
	Environmental Management Bureau	・Investigative research on the biological effect of environment nanoparticles
	Environmental Health Department	・Research on the actual state of POPs contamination ・Basic research for hazardous heavy metal countermeasure strategy ・Comprehensive promotion fund for GHS (globally harmonized system of classification and labeling of chemicals)

3.2.2.4 Nanotechnology and Materials

The nanotechnology and materials field contributes in the progress of science and technology and problem solving in fields such as life sciences, information and communications, environment, energy, MONODZUKURI technology, infrastructure and frontiers. It forms important technology seeds that realize the development of industry, affluent lives for people and safe, assuring and comfortable society.

(1) Nanoelectronics area

MEXT is developing logic devices that break the limitation of silicon devices, information memory with 100-fold memory density compared to conventional products, and devices with new principles using nanotechnology. The Ministry also develops information communication materials utilizing nanotechnology through the National Institute for Materials Science.

METI is developing nanoelectronics technology that is able to improve the function of and reduce the energy consumption by next-generation semiconductors, displays, memory storage and network devices.

(2) Nanobiotechnology and biomaterial area

MEXT is establishing nanobiotechnology research bases open to the world. At the same time, it is developing biomaterials including artificial bones and livers. The Ministry is also developing biomaterials utilizing nanotechnology through the National Institute for Materials Science.

MAFF is utilizing biofunction information to promote the development of groundbreaking new functional materials by structure control at the nano-level, development of technology to utilize groundbreaking biofunctions, and the building of a micro-bioreactor.

Since Fiscal 2005, the METI has been developing molecular imaging equipment to identify changes in cell functions and enable the very early detection of cancer, as well as equipment to combat cancer cells only.

MOE implemented the development of technology for the supersensitive and prompt detection of hazardous chemical substances by artificial tissue-nanodevice sensor complex.

(3) Materials area

As strategically focused science and technology, the Fire and Disaster Management Agency is developing components to utilize nanotechnology materials for firefighting clothing. The Agency is also implementing research on the evaluation methods of the performance functions such as heat resistance.

MEXT is promoting research and development on innovative catalysts with structural design and control at the nano-scale, and highly-functional structures with high-specific strength. The Ministry is also promoting research and development on the sophistication of environmental/energy materials and materials with high reliability and safety, through the National Institute for Materials Science.

METI is developing fundamental technology that is necessary to realize key materials essential for information communication devices such as next-generation semiconductors, displays, memory storage and network devices with high performance but which consume less energy.

The Ministry of the Environment implemented the development of environmental technologies that make use of the nanotechnology merits of miniaturization and improved function.

(4) Area of promotion basis for nanotechnology/material fields

MEXT is promoting the "Development and Utilization of X-ray Free Electron Laser" that enables the instant measurement and analysis of the ultrafine structure of a substance to a single atom level and ultrahigh-speed dynamic state and changes in chemical reactions. The Ministry is also providing broad, cross-cutting and integrated support that goes beyond the bounds of existing research institutions and sectors, such as offering opportunities for the utilization of large and special facilities and equipment to outside researchers, collecting and publishing relevant information, convening symposiums, and fostering human resources through seminars and international exchanges of young researchers, through the "Nanotechnology Comprehensive Support Project." In addition, the Ministry is implementing research and development based on mid- and long-range outlooks under the close cooperation of researchers, through the "Virtual Laboratory in Nanotechnology Areas," in the Basic Research Program by the Japan Science and Technology Agency.

METI is promoting the "Nanotechnology Materials

Program" to strengthen the collaboration between upstream and downstream industries in order to improve technical capabilities and the international competitiveness of industries in Japan.

(5) Nanoscience/material science area

MEXT is engaged in basic research including next generation nano-science technology research on the measurement and control of nano-level properties and functions, the development of new information processing devices, manufacturing of auto-changing, auto-reacting materials, and materials that can change over time, and nano-scale structure observation using light, through RIKEN. Moreover, many universities and colleges and independent administrative institutions are engaged in basic research spanning a wide range of fields.

Major research subjects conducted during Fiscal 2006 for the nanotechnology/materials field are as shown in Table 3-2-4.

Table 3-2-4 Major research subjects in the nanotechnology and materials sectors (FY2006)

Ministry or agency	Research institute or program	Subject
Ministry of Internal Affairs and Communications	National Institute of Information and Communications Technology, etc.	・Research and development of ultra functional network technologies utilizing nanotechnology ・Research and development related to nano-ICT
	National Research Institute of Fire and Disaster	・Research on the development of material elements for firefighting clothing using nanotechnology and evaluation methods thereof
Ministry of Education, Culture, Sports, Science and Technology	Promotion of Novel Interdisciplinary Fields Based on Nanotechnology and Materials	・Development of processing device based on non-silicon device materials ・Development of memory devices for ultrahigh density information ・Founding biotechnology research centers ・Development of environmental functional catalyst based on nanotechnology ・Development of microstructure-controlled materials
	Research and Development Project for Economic Revitalization (Leading Project)	・Development of devices with new principles utilizing nanotechnology ・Development of artificial organs utilizing nanotechnology ・Development of ultrasensitive NMR (nuclear magnetic resonance apparatus) ・Practical development of nano-measurement/processing technologies ・Practical use of manufacturing technology for advanced semiconductors, including the development of extreme ultraviolet (EUV) light source ・Next generation fuel cell project
	New Century Priority Research Creation Plan 2002 (RR2002)	・Nanotechnology Comprehensive Support Project
	National Institute for Material Science	・Development of common fundamental areas in the nanotechnology field ・Creation and nanostructure control of nano-scale new materials ・Development of information and communication materials utilizing nanotechnology ・Development of biomaterials utilizing nanotechnology ・R&D for improving environmental/energy materials ・R&D on materials ensuring high reliability and safety
	RIKEN (The Institute of Physical and Chemical Research)	・Nano-scale science and technology, electron complex matter science research ・Research on exotic particle beams, study on the genesis of matter ・Advanced technology research (physical science research), material science research (Quantum materials research) ・Spatio-Temporal Function Materials Research, Single Quantum Dynamics Research ・Extreme photonics research ・Molecule ensemble research
	Japan Science and Technology Agency	・Creation of ultra-fast, ultra-power-saving high-performance nanodevice systems, creation of bio-elements and systems utilizing medical-oriented chemical and biological molecules, and other projects for the promotion of strategic creative research
Ministry of Health, Labour and Welfare	Health and labour science research grants	・Research on advanced medical technology
	Health Policy Bureau	・Research on the application of nano-level imaging in medical area ・Research on the development of microscopic medical equipment operational technology ・Research on drug delivery system ・Research on extra-early diagnostics of illness and medical treatment system
Ministry of Agriculture, Forestry and Fisheries	National Agriculture and Food Research Organization	・Development of nanotechnology and materials technology for innovative utilization of biological functions
Ministry of Land, Infrastructure and Transport	Technology Research Division, Minister's secretariat	・Development of performance assessment method of novel structure buildings using innovative structural material such as high-tension steel, etc.
	Policy Bureau	・Research on the reduction of the effects on the environment in the transportation field utilizing nanotechnology

Ministry or agency	Research institute or program	Subject
Ministry of Economy, Trade and Industry	National Institute of Advanced Industrial Science and Technology	・Development of self-assembly technology ・Development of strongly-correlated electron materials and devices ・Survey on the social influence of nanotechnology
	New Energy and Industrial Technology Development Organization	・Project for R&D on Next-generation DDS Therapy Systems for Deep Therapy ・R&D of Molecule Imaging Equipment ・R&D on the practical use of nanotechnology and advanced materials ・Project on the development of carbon nanotube capacitor ・Spintronics nonvolatile function technology project ・Technology for highly-efficient manufacturing of three-dimensional optical device ・Forged Magnesium Parts Technological Development Project (Development of Foundation Technology on Advanced Material for the Creation of New Industry) ・Project for the practical use of advanced analytical instrument (Development of Foundation Technology on Advanced Material for the Creation of New Industry) ・Development for foundation technology on materials for textiles with new structure with advanced function expression (Development of Foundation Technology on Advanced Material for the Creation of New Industry) ・Development of an evaluation basis for the development of next generation advanced material (Development of Foundation Technology on Advanced Material for the Creation of New Industry) ・Technology development for ultra-flexible display material (Development of Foundation Technology on Advanced Material for the Creation of New Industry) ・Technology development for low-loss optical materials with new functions (Development of Foundation Technology on Advanced Material for the Creation of New Industry)
Ministry of the Environment		・Environmental technology development and promotion operations utilizing nanotechnology

3.2.2.5 Energy

Three years have passed since the "Basic Energy Plan" was developed in October 2003, which was based on "the Basic Law on Energy Policy" (Law No. 71, June 2002), and the Plan was revised in consideration of the changes in the situation concerning energy that occurred during that time (decided by the Cabinet meeting on March 9, 2007). The Plan presents the measures for energy research and development that should be predominantly promoted in order to develop countermeasures for the energy supply and demand in a comprehensive and planned manner on a long-term basis.

(1) Diversification of energy sources (Promotion of the use of nuclear energy)

Today, nuclear power generation accounts for approximately one-third of the total power generation in Japan, and may become a quasi-domestic energy and excels in stability of supply. In addition, since nuclear power generation has the feature that no carbon dioxide is discharged through its power generation process and can contribute to mitigate global warming, it is planned that the development of nuclear power generation should be continued by ranking it as the basic power source in the future.

Research, development, and utilization of atomic energy in Japan have been conducted according to the "Atomic Energy Basic Law" (enacted in December 1955), solely for peaceful purposes, based on the premise of ensuring safety, and the Government has been steadily promoting the research, development and utilization of nuclear energy based on the "Framework for Nuclear Energy Policy" (October 2005) and the "Basic Energy Plan".

1) Next-generation LWRs and advanced use technology for LWRs

Concerning the Light Water Reactors (LWRs), the main type of nuclear reactors used in Japan, the introduction of the Pressurized Water Reactor (PWR) and the Boiling Water Reactor (BWR) from abroad started in the Showa 40's (1965-1974), and the establishment of domestic technology has been promoted. Afterward, since the Showa 50's (1975-1984), a shift to domestic production of LWRs has been promoted by conducting the "Standardization Program", a technology development program with full cooperation of governmental and private sectors, while incorporating the past operating experiences and basic research results. Under the "Third Improvement and Standardization Program" that was started in 1981, new types of domestic LWRs (APWR and ABWR) were developed aiming at further improvement in safety, reliability and economic competitiveness, as well as the reduction of radiation exposure to employees, while conducting international cooperation. The first ABWR units, Unit 6 and 7 at the Kashiwazaki Kariwa Nuclear Power Station, were commissioned in 1996.

In addition, it was decided that a domestic next-generation LWR should be developed with full cooperation of governmental and private sectors in preparation for the large-scale demand for replacement of

the existing nuclear power plants (NPPs) in Japan, which is expected to begin in approximately 2030, and a feasibility study (FS) for the development was initiated in fiscal 2006.

2) Fast Breeder Reactor (FBR) cycle technology

The Fast Breeder Reactor (FBR) cycle technology, a strategic priority subject in science and technology, was selected as a key technology in the "Science and Technology Basic Plan" (i.e., key technologies of national importance) in which concentrated investments should be made during the basic plan period as a large-scale national project.

The Prototype Fast Reactor "Monju" has been shut down since the sodium leak accident that occurred in December 1995. However, the Japan Atomic Energy Agency (JAEA) has performed modifications aiming to restart safety-based operation, and started the plant construction in December 2006.

The "Nuclear Energy National Plan" (August 2006) was concluded by the nuclear power subcommittee at the Advisory Committee on Natural Resources and Energy of the Ministry of Economy, Trade and Industry. Then, "Policies concerning Research and Development of a Fast Breeder Reactor Cycle" (October 2006) was concluded by the Panel for R&D on Nuclear Energy at the Research Planning/Evaluation Committee of the Council for Science and Technology of the Ministry of Education, Culture, Sports, Science and Technology as a response to the final report on Phase II of the Feasibility Study on Commercialized Fast Breeder Reactor Cycle Systems. In addition, "Basic Policy on Research and Development of FBR Cycle Technologies over the Next Decade" (decided by the Atomic Energy Commission in December 2006) was announced (Figure 3-2-5).

Under these policies, the combination of "sodium-cooled fast breeder reactor/ advanced aqueous process reprocessing/ simplified pelletizing fuel fabrication" was selected as the most promising commercial system concept (main concept). It was then evaluated as the highest degree of feasibility, and the research and development would be promoted by the "Fast Reactor Cycle Technology Development Project" for the full-scale demonstration and commercialization of the FBR cycle from a wide range of strategic studies that are already completed (Figures 3-2-6 and 3-2-7).

Under the Fast Reactor Cycle Technology Development Project, the research and development is planned to be conducted for the commercialization of the FBR cycle, reflecting the achievements of Monju. This will lead to achievement of the development targets: safety, economic competitiveness, efficient utilization of nuclear fuel resources, reduction of environmental burden and enhancement of nuclear non-proliferation in 2015. It is planned to make a judgment about the adoption of innovative technologies for the commercial facilities in 2010, conduct the development of elemental technologies while enhancing international cooperation, and to perform design study based on the development results.

Significance of the Fast Breeder Reactor (FBR) cycle Research and Development (R&D)

Future outlook and problems

- ○ The world's energy demand will increase threefold or more compared with the present level by the year 2100.
  - → Increased competition for securing energy resources
- ○ Production of CO2 associated with fossil fuel consumption
  - → Coping with the global warming issues

Significance of nuclear power generation

- ○ Placed as a quasi-domestic energy resource
  - → Contribution to stable energy supply
- ○ No CO2 emission in the electric power generation process
  - → Contribution to countermeasures against global warming
- → Crucial role as a basic power source

Significance of the FBR cycle

- ○ Capable of dramatically boosting the efficiency of uranium resource utilization and using nuclear power generation over several centuries or more
  - → Contribution to stable energy supply
- ○ Reduction of environmental burden of radioactive waste

→ Enhancing opportunities for R&D of the FBR cycle in various countries

(USA) A prototype reactor (to be commissioned in approximately 2020), etc. are in the planning stage.
(France) A prototype reactor is in the planning stage (to be commissioned in 2020).
(Russia) Demonstration reactors are under construction.
(China) An experimental reactor is under construction. (scheduled to reach criticality in 2008)
(India) A prototype reactor is under construction (to be commissioned in 2010).

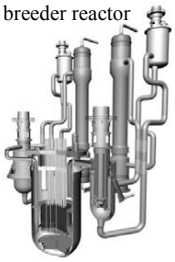
It is necessary for Japan to perform R&D aiming for the FBR cycle as a main power source from the perspective of contribution to stable energy supply, contribution to countermeasures against global warming, and the reduction of environmental burden of radioactive waste.

Selecting the main concept that will be a main subject for future R&D

(Performing intensive R&D of a commercial system concept that is evaluated to have the highest feasibility as a commercial facility in light of the present knowledge)

The combination of "Sodium-cooled fast breeder reactor (with MOX fuel), Advanced aqueous reprocessing and Simplified pelletizing fuel fabrication" was selected.

Fast breeder reactor



Fuel cycle facilities (Reprocessing and Fuel fabrication facilities)

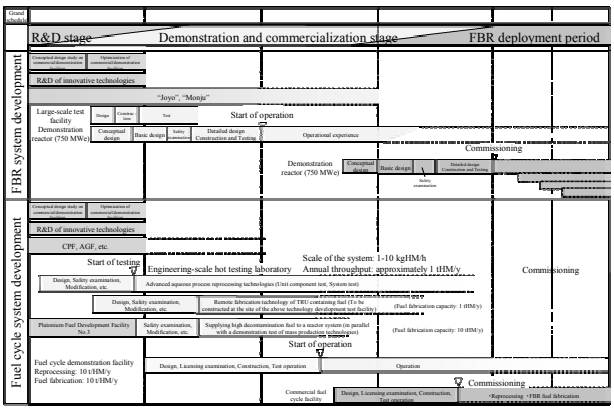
Future development targets
- ■ Safety
- ■ Economic competitiveness
- ■ Reduction of environmental burden
- ■ Effective nuclear fuel resource utilization
- ■ Enhancement of nuclear non-proliferation

Expected effects
- ○ No need to import nuclear fuel beyond 2100
- ○ Reducing the amount of high level radioactive waste per unit power generation to approximately 1/4
- ○ Further enhancement of nuclear non-proliferation by technical means

*The combination of "Sodium-cooled fast breeder reactor (with metal fuel), Metal electrolytic process reprocessing and Injection casting process fuel fabrication" is ranked as a complementary concept, which will be addressed as a fundamental R&D subject, because it has larger uncertainty in social and technical perspectives compared with the main concept.

Research and development strategy until 2015

R&D roadmap aiming for commercialization



*This roadmap was prepared for the development of the R&D program until 2015.

R&D program until 2015

From the Feasibility Study on Commercialized FBR Cycle systems to the FBR Cycle Technology Development Project

- ●2010: Decision of innovative technologies to be adopted
  - ・ Reactor: 13 subjects
  - ・ Reprocessing: 6 subjects
  - ・ Fuel fabrication: 6 subjects
- ●2015: Presentation of a commercialization image and an R&D program
  - ・ Conceptual design of the demonstration facility and commercial facility (for the FBR cycle deployment and equilibrium periods)
- ● Resumption of the operation, "demonstration of reliability as a power-generating plant" as well as the accumulation of operational experiences aiming for the establishment of sodium handling technologies at Monju

R&D strategy

1) Securing safety
2) Promoting international cooperation
3) R&D organization
4) System for R&D evaluation
5) Ensuring R&D resources
6) Enhancing activities for achieving the accountability

Figure 3-2-5 Basic policy on promoting the research and development for the fast breeder reactor and its fuel cycle

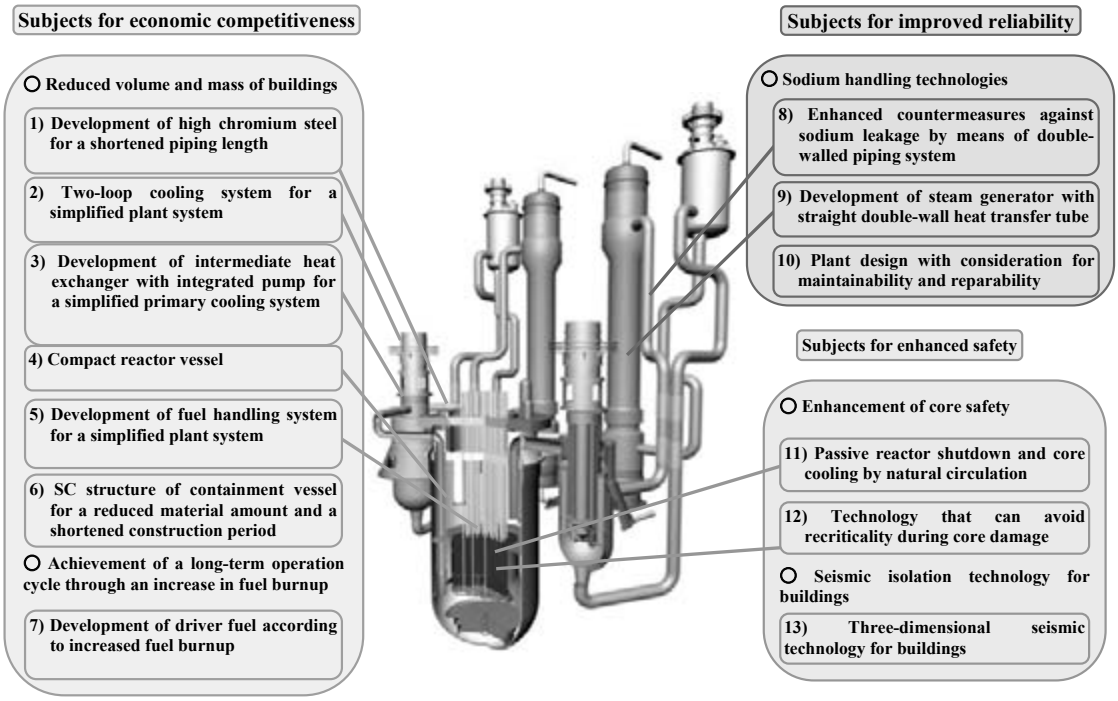


Figure 3-2-6 Technology development for sodium-cooled reactor

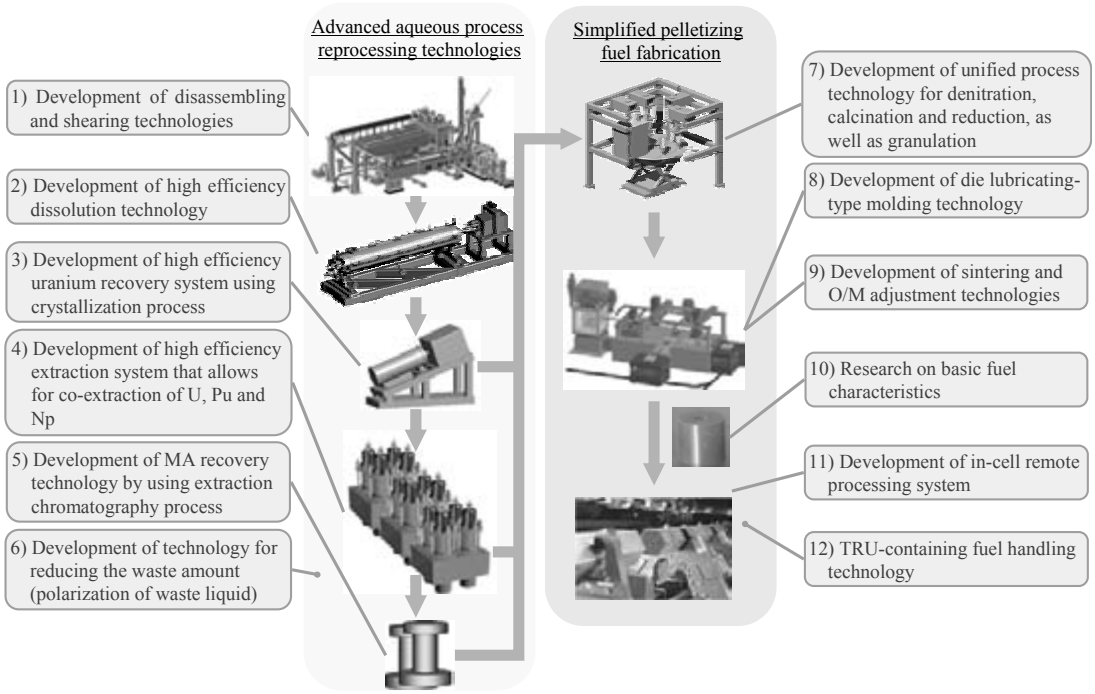


Figure 3-2-7 Technology development for advanced aqueous process reprocessing and simplified pelletizing fuel fabrication

In addition, a "Five-party council" was established in July 2006: it consists of members from METI, MEXT, electric power companies, manufacturers and JAEA. In December 2006, the council decided on a policy for the research and development framework to be applied until the start of basic design of a demonstration fast breeder reactor. In this framework, a single leading manufacture takes responsibility for an efficient FBR development (Figure 3-2-8).

3) Uranium enrichment and advanced fuel

Japan has to rely on imports for most of its energy resources. Japan is steadily promoting efforts to establish the fuel cycle through effective utilization of the recovered plutonium, etc., from the reprocessing of spent nuclear fuel, in order to secure long-term energy supply stability in view of the future energy supply and demand in the world, and to reduce the load on the environment.

In promoting plutonium utilization, Japan strives to ensure the transparency of plutonium use by disclosure of information regarding plutonium inventories, not only from the viewpoint of rigorous management of nuclear materials, but also in clear observation of the principle of never holding excess plutonium that is not required to implement current programs, so as to avoid arousing international concerns regarding the proliferation of nuclear weapons. In particular, the "Management Status of Plutonium in Japan" is annually reported to the Atomic Energy Commission of Japan and announced to the public, and also reported to the International Atomic Energy Agency (IAEA) according to Guideline for the Management of Plutonium for improving the transparency of plutonium use. Moreover, electric power companies announce their utilization plans in which the purposes of their plutonium use are described, and the Atomic Energy Commission assesses the plans.

Concerning the enriched uranium used as fuel in nuclear power generation, Japan is promoting the development of domestic uranium enrichment projects to secure independence over the entire nuclear fuel cycle, and endeavoring to maintain economy.

At present, research and development of an advanced centrifuge machine, which has higher performance and excels in economic competitiveness, is in progress with close cooperation of governmental and private sectors, aiming at deployment in approximately 2010.

Research and development organization for FBR commercialization

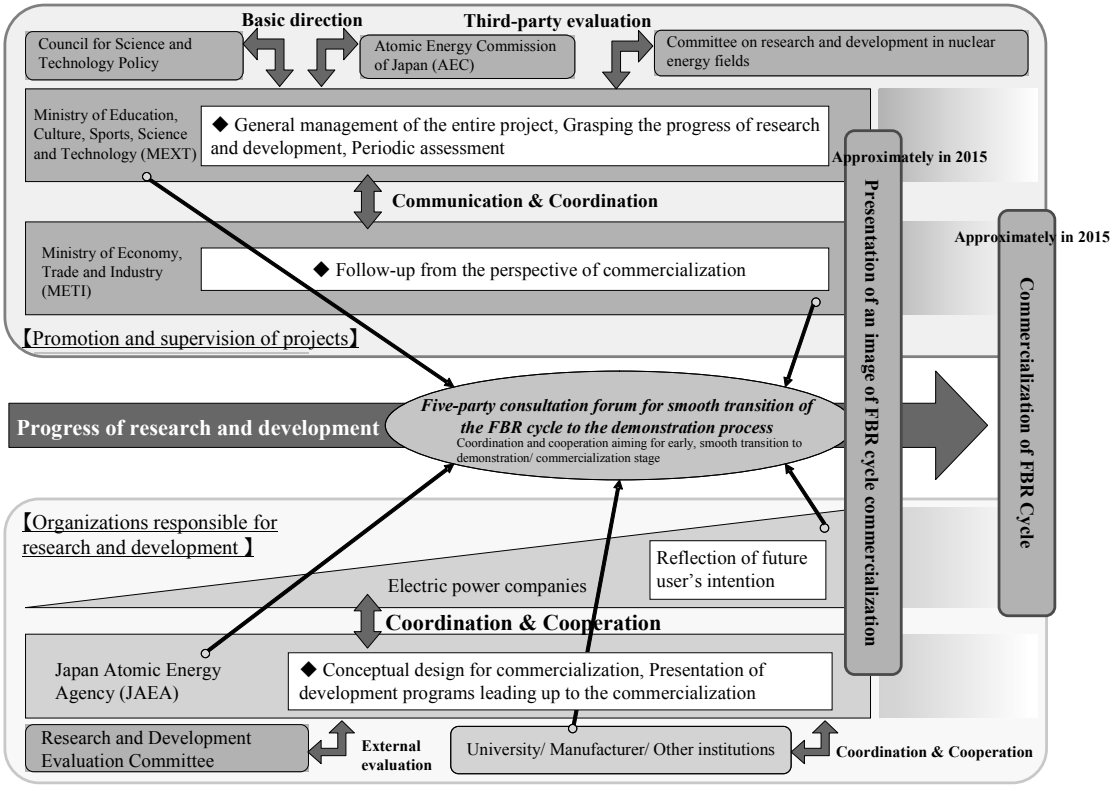


Figure 3-2-8 Research and development organization for FBR commercialization

4) Spent fuel reprocessing technology

While some reprocessing of spent fuel from nuclear power plants is conducted at JAEA's Tokai Reprocessing Plant, most of the spent fuels are consigned by contract to reprocessing by British Nuclear Fuel Limited (BNFL) and COGEMA, the French nuclear fuel company.

In view of the principle that spent fuel should be reprocessed domestically in Japan, construction is underway on a private-sector reprocessing facility (with an annual reprocessing capacity of 800 tons) in Rokkasho-mura, Aomori Prefecture, and testing at the final stage (active testing) is in progress using the spent fuel aiming at the completion of construction in November 2007. Construction and operation of the Rokkasho reprocessing plant is aimed at steady establishment of the reprocessing technology on a commercial scale, as well as the evolution toward establishment of the nuclear fuel cycle.

The Tokai Reprocessing Plant, which had been reprocessing spent uranium fuel used in light water reactors under contracts with electrical power companies, completed this work in March 2006. As a result, about 1,100 tons were reprocessed in total.

The "Fugen" advanced thermal reactor, which was undergoing independent development as a nuclear reactor with the ability to flexibly and efficiently utilize plutonium, recovered uranium, and other fuel, terminated its operations in March 2003, and the project ends as of 30 September 2003 with the completion of a report summing up the project results. The R&D necessary for decommissioning is now in progress.

5) Geological disposal of the high-level radioactive waste

Research and development of the geological disposal of high-level radioactive waste, which is a strategic priority subject in science and technology essential for Japan to establish a technology that supports the national safety regulation regime as well as to conduct the final disposal of high-level radioactive waste and other waste, and hence, needs steady promotion. Research and development of this technology is being conducted in close cooperation with the relevant research institutions centered on the Japan Atomic Energy Agency (JAEA). In addition, the JAEA is developing two underground research laboratory programs in Mizunami, Gifu Prefecture (crystalline rocks) and in Horonobe, Hokkaido Prefecture (sedimentary rocks) as key facilities for promoting its research and development.

6) Technologies for decommissioning of nuclear facilities and treatment/disposal of radioactive waste

It is important that decommissioning of nuclear facilities and treatment/disposal of radioactive waste should be conducted under the responsibility of nuclear facility establishers and radioactive waste generators in a planned and efficient manner. JAEA is developing decommissioning engineering systems and radioactivity measurement/evaluation technologies. These are for the purpose of implementation of safe and rational decommissioning of nuclear facilities, treatment/disposal of radioactive waste, and reduction in the amount of radioactive waste as well as reusing the generated waste for resources.

7) Nuclear fusion energy technology

Promotion of nuclear fusion research and development is important for expanding available energy options in the future. In Japan, JAEA, the National Institute for Fusion Science, and universities are engaged in fusion research and development through mutual cooperation. Japan is also promoting bilateral and multilateral cooperation actively.

JAEA has been pushing forward R&D on the tokamak type reactor[10] to realize a practical reactor. In particular, JT-60, as large tokamak device, has achieved significant results which have led the physics R&D for the ITER[11], and the demonstration of steady-state fusion reactor. It now targets the long pulse operation of high pressure plasma through the improvement of plasma confinement performance.

The National Institute for Fusion Science constructed the largest helical[12] device (LHD) in the world that is based on a unique idea originated in Japan. Its research in the new plasma field leads the world.

In addition, the Institute of Laser Engineering at Osaka University, other universities and independent administrative institutions, etc. are performing basic research into various magnetic confinement and inertial confinement methods, and research into essential technologies related to reactor engineering.

The ITER project is an international cooperation project that aims to demonstrate the scientific and technological feasibility of nuclear fusion energy, and Japan is working on this project responsibly and actively

[10] Tokamak method: A method for confining plasma inside a donut-shaped magnetic field that is produced with a toroidal field coil and central solenoid coil.
[11] "ITER" is International Thermonuclear Experimental Reactor, and also means "(long) way" in Latin.
[12] Helical method: A method for confining plasma inside a donut-shaped magnetic field, as in the Tokamak method, however, tortuous-shaped coils are used.

as a strategic priority subject in the basic plan of science and technology. After the ITER site was decided in Cadarache, France in June 2005, the Agreement on the Establishment of the ITER International Fusion Energy Organization and the agreement on its tentative application were signed in Paris in November 2006. Then, the ITER International Fusion Energy Organization tentatively started to prepare the ITER construction. In such a way, the ITER project is being promoted significantly.

In addition, when the ITER site was determined, Japan and EU was decided to conduct a complementary R&D project (the Broader Approach) in parallel with the ITER project and signed the joint implementation agreement on the Broader Approach in February 2007. According to this agreement, the base for international R&D is being established in Japan to perform R&D aiming at the realization of the demonstration reactor, a target after the ITER.

8) Basic and fundamental R&D for nuclear science, R&D for nuclear non-proliferation technology, etc.

a) Basic and fundamental R&D for nuclear science

Basic and fundamental R&D for nuclear science is important to maintain the technical basis concerning nuclear power utilization at a high level, as well as to support utilization and development of nuclear energy by creating new knowledge and technology. JAEA is conducting advanced basic research, such as nuclear science on super-heavy elements and fundamental nuclear engineering, including reactor engineering, nuclear data, nuclear materials, environmental engineering, radiation protection and radiation engineering. Such fundamental nuclear engineering also includes research on separation and transmutation technology aiming at reduction in burden of waste treatment, research on material behavior aiming at efficient development of nuclear fuel and materials, as well as technical development of environmental analysis that supports nuclear non-proliferation technology.

b) Nuclear non-proliferation

The IAEA safeguards have been implemented in Japan to ensure the peaceful use of nuclear materials, based on the Safeguards Agreement with the IAEA. Japan has implemented "physical protection" to prevent theft of nuclear materials or attempts to sabotage nuclear facilities accordant with the international level. In addition, Japan is promoting the development of technologies that are necessary for the implementation of the above measures.

In June 2004, the IAEA first concluded that there was no indication of the diversion of nuclear materials placed under safeguards and no indication of undeclared nuclear materials or activities in Japan in 2003. Since then, the IAEA has drawn the same conclusion for Japan every year. Based on the conclusion, the Integrated Safeguards, which are more efficient safeguards that may enable a reduction in the number of the IAEA's inspections, have been implemented.

In addition, in order to implement effective and efficient safeguards for important facilities to be safeguarded, including the Rokkasho Reprocessing Plant which is in process of active tests and is scheduled to be completed in November 2007, as well as the Rokkasho MOX fuel fabrication facility which is scheduled to start construction in October 2007, the government is engaged in system development, including the establishment and advancement of safeguards measures. The government also organized an international training course for the improvement of technologies for nuclear materials accounting.

JAEA is performing the technology development for safeguards, development of technologies for facilitating more efficient, and effective nuclear material management, as well as the development of safeguards technology for a next-generation nuclear system.

In addition to the responsibilities of the NPT (Treaty on the Non-Proliferation of Nuclear Weapons), it is important for Japan to enhance transparency by employing rational and consistent plans, while adhering strictly to the principle of not possessing plutonium reserves for which the purpose of utilization is unspecified. Therefore, in line with international plutonium guidelines designed to boost transparency of the nuclear fuel cycle program, Japan discloses through the IAEA the conditions of its plutonium management, and independently discloses more detailed data, to ensure that transparency is maintained at a level as high as possible. Furthermore, Japan actively promotes the development of technologies related to non-proliferation policy, and undertakes research and development activities with full consideration of nuclear non-proliferation in fields such as advanced recycling technologies.

Moreover, in July 1997, Japan ratified the CTBT (Comprehensive Nuclear-Test-Ban Treaty) banning any nuclear weapon test explosion or any other nuclear explosion, and Japan is making every efforts to install and operate International Monitoring System facilities which can detect radio nuclides.

9) Innovative nuclear energy system technologies including the high temperature gas-cooled reactor

Effective use of nuclear fuel resources and a wide variety of uses of nuclear energy by promoting research and development of innovative nuclear energy systems are important to ensure the diversity and flexibility of energy supply.

JAEA is promoting performance evaluation of the high temperature gas-cooled reactor by means of the test operation of the High Temperature Engineering Test Reactor (HTTR) as well as the research and development of the IS process in which hydrogen is produced by pyrolysis of water, in order to establish high temperature gas-cooled reactor technology, which allows for various types of energy supply and heat utilization technologies such as hydrogen production.

(Ensuring nuclear safety)

Safety is the indispensable prerequisite for the research, development, and utilization of nuclear energy. Enforcement of stringent regulations and safety management, and execution of safety research, are essential to ensuring safety. Moreover, in recognition of the impossibility of eliminating the occurrence of accidents to 0%, there is also a need to prepare countermeasures in the case of an accident to ensure that damage to the lives and health of local residents, etc. is held to the absolute minimum.

Because of these viewpoints, the government imposes stringent safety regulations on nuclear facilities in the design, construction, and operation stages of nuclear energy research, development and utilization, to a degree unseen in any other industrial sector in Japan. In addition to regulations, the government also has adopted various kinds of measures to ensure safety, such as environmental radiation monitoring and emergency preparedness.

With regard to the ensuring of safety at nuclear facilities, the amended Law on the Regulation of Nuclear Source Materials, Nuclear Fuel Materials and Reactors was enforced on December 1, 2005. These amendments aimed at strengthening the system to protect nuclear materials, introducing the clearance system[13] and enhancing the regulation system concerning the dismantling and abolition of nuclear facilities.

To introduce the international standard value (lower limit of the subject of regulations) set by the International Atomic Energy Agency (IAEA) and streamline the regulations of radioactive isotopes along with their introduction, the amended Law concerning Prevention from Radiation Hazards Due to Radio-Isotopes, Etc[14] , was enforced in June 2005.

Regarding nuclear emergency countermeasures, efforts to expand and strengthen nuclear disaster measures are now being promoted based on the Special Law of Emergency Preparedness for Nuclear Disaster, including the dispatch of the Senior Specialists for Nuclear Emergency Preparedness, designation of base facilities for emergency measures in urgent situations (off-site centers), etc., preparation of radiation measurement equipment and other necessary materials and equipment, preparation of disaster prevention plans for nuclear energy companies and implementation of emergency drills.

For surveys of environmental radiation, the Ministry of Education, Culture, Sports, Science and Technology and other relevant ministries and agencies, prefectural governments, and atomic energy enterprises continue to conduct radiation surveys in areas surrounding nuclear facilities. In addition, surveys of environmental radioactivity level in Japan are conducted, as well as radiation surveys of nuclear-powered military vessels when they enter port. When North Korea announced the conducting of underground nuclear testing in October 2006, MEXT and the relevant ministries and agencies strengthened the radioactivity measurement system based on an agreement at the leading director meeting in the interministerial consultation committee on counter -radiation measures, which was held at Cabinet Secretariat, and investigated the effects on the interior of Japan. MEXT compiled the measurement results and announced to the public through Cabinet Secretariat that no abnormality was detected.

Based on the Priority Safety Research Program on Nuclear Energy, which was decided by the Nuclear Safety Commission in July 2004, research concerning those fields, including the regulatory systems, light water

[13] Clearance: Removal from control of radioactive materials, of which the radiation level is sufficiently small compared to the radiation levels in the natural world and of which the effect on human health is negligible, as "those which do not require treatment as radioactive materials".

[14] The following amendments were made through amendments to the Law concerning Prevention from Radiation Hazards Due to Radio-Isotopes, Etc. in 2004:
(1) creation of a system of design certification for the equipment manufacturers
(2) streamlining the procedure for sales and leasing services from a license system to a notification system
(3) creation of a regular confirmation system to improve the safety of establishments
(4) creation of a regular training system to improve the ability of radiation protection supervisors
(5) preparation of provisions concerning disposal of waste by burial

reactors, nuclear fuel cycle facilities, radioactive waste and decommissioning, advanced nuclear reactors, radiation effects, as well as the nuclear disaster countermeasures, are steadily conducted by the JAEA, the Japan Nuclear Energy Safety Organization, and the National Institute of Radiological Sciences.

With consideration that electric power companies announced the hidden incidents from authorities with regard to the automatic shutdown of electric power reactors, MEXT issued direction to the JAEA, universities and private company to check the existence or nonexistence of hidden incidents with regard to the automatic shutdown of research reactors. Concerning the 10 reactors of the JAEA, MEXT confirmed that no hidden incident required by law to be reported exists in any reactor and announced this result to the public on March 30, 2007. Concerning the remaining 5 reactors of universities and private company, the reviews are still ongoing (as of April 2007).

In addition, JAEA is voluntarily conducting the review of Monju, Fugen and the Tokai Reprocessing Plant, and MEXT received a tentative report that neither an undeclared report with regard to the unscheduled shutdown nor an example of critical accident during shutdown was found. Concerning these facilities, voluntary review required is planned to be continued (as of April 2007).

(Promotion of nuclear science and technology, and development of infrastructure for the research, development and utilization of nuclear power)

1) Promotion of nuclear science and technology

Nuclear science and technology includes basic and fundamental research that explores the basic principles of nature and supports development in various science and technology fields, including the life science and materials science, by means of development and utilization of quantum beam technology such as accelerators and high intensity lasers.

With respect to the quantum beam technology, JAEA and the High Energy Accelerator Research Organization (KEK) have been jointly promoting the Japan Proton Accelerator Research Complex (J-PARC project), which aims at new developments over a wide range of research fields, including life science, material science, nuclear physics and particle physics by generating and utilizing proton beams with the highest beam power in the world. The project is in progress towards the commissioning in fiscal 2008. In addition, RIKEN (The Institute of Physical and Chemical Research) is developing the "RI Beam Factory" (RIBF), an accelerator facility that generates beams of all types of radioactive isotopes (RI), from hydrogen to uranium, with the highest intensities in the world. RIKEN launched the operation of the RI beam generation system in fiscal 2006, and is developing experimental installations to start full-scale experiments.

Furthermore, national scientific research institutions under the control of each office and ministry are promoting cutting-edge basic research in the three areas of fundamental technology, i.e. substances and materials, biological and environmental effects, and system. In addition, the Nuclear Energy Fundamentals Crossover Research is being conducted to promote research and development under active interaction among research institutions on various elements of technology development that are difficult to be promptly achieved by individual research institutions.

2) Dissemination of radiation utilization

Since radiation is used in a wide range of fields from basic and applied research to practical use in medicine, engineering, agriculture, etc. It is important to promote the dissemination of radiation utilization while conducting the research and development.

As for the state of radiation utilization, the medical sciences already make wide use of diagnostic technology employing X-ray Computerized Tomography (CT) and X-ray or gamma ray radio-therapy for the treatment of cancer, while research is being conducted on the use of protons and heavy ion beams, etc., for the treatment of cancer. In particular, the National Institute of Radiological Sciences (NIRS) is engaged in research on the cancer therapy using heavy ion beams, which is highly anticipated for its clinical effectiveness against cancer, and the institute has treated more than 3,000 cancer patients as of December 2006.

In addition, research to downsize equipment is being performed, and based on the results, Gunma University started the construction of a technology demonstration unit in fiscal 2006. Research is progressing into the diagnosis and treatment of cancer using proton beams at Tsukuba University's Proton Medical Research Center and other institutions.

In the agricultural sector, radiation is used for the improvement of crop varieties, the prevention of budding in potatoes, etc. In the industrial sector, radiation is used for non-destructive testing, for industrial measurements, and for quality improvements of polymer materials. In

addition, development of environmental protection technologies using ion beams, gamma radiation and electron beams is in progress.

3) Disposal of radioisotope and research institute waste

At present, radioactive waste that is generated from research institutes and medical facilities (RI (Radioisotope) and research institute waste) is not disposed of but stored by individual entities, however, it is an important subject to realize the disposal of this waste for the promotion of research, development and utilization of nuclear energy in the future.

For this purpose, a report on the implementation structure for the disposal project and the preferable way of ensuring budget for disposal was compiled under the Panel for R&D on Nuclear Energy at the Research Planning/Evaluation Committee of the Council for Science and Technology in September 2006. Based on this report, MEXT is conducting a study toward the achievement of the disposal.

4) Efforts for assuring trust and coexistence with communities

In order to promote smooth research, development, and utilization of nuclear energy, it is extremely important to obtain public confidence in nuclear power. For this purpose, nuclear power operators must build up a record of safe operations, and strive to win public understanding. To this end, public hearings and public relations programs are being promoted to ensure two-way communication and transparency, and activities aiming at better understanding, such as the training of teachers about nuclear energy or the lending out of simplified radiation detectors, are being conducted.

Furthermore, to promote coexistence between nuclear power research facilities and regions where there nuclear facilities located, the Power Source Grant program and other measures are being utilized in response to the needs of the regional communities.

5) International nuclear power cooperation

In the area of international nuclear cooperation, international cooperation is being actively promoted under the policy of the promotion of international cooperation such as exchange of information and experiences through international organizations, with basic premises of the peaceful use, in a manner of ensuring nuclear non-proliferation, safety and nuclear security.

For nuclear cooperation with Asian countries, exchanges of information, opinions, and technology are being promoted by holding workshops under the framework of the FNCA (Forum for Nuclear Cooperation in Asia[15]) in which Japan plays a leading role, and cooperative research is being performed under the framework of RCA (Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology[16]), a part of IAEA activities. In addition, training projects for Asian countries are conducted to improve the qualifications of nuclear personnel.

Japan actively participates in the GIF (Generation-IV International Forum[17]), a framework for international cooperation which promotes research and development of the advanced nuclear energy system, and plays a leading role in the discussion on the sodium-cooled fast reactor.

In addition, Japan supports the GNEP (Global Nuclear Energy Partnership[18]) vision, which was proposed by the United States in February 2006 to ensure nuclear non-proliferation in parallel with acceptance of world-wide development and expansion of the nuclear power generation, and is actively promoting cooperation with the U.S. relating to this concept.

Moreover, Japan continues the provision of multilateral support through extra-budgetary contribution funding to the IAEA and OECD/NEA (Organisation for Economic Co-operation and Development/ Nuclear Energy Agency), as well as a bilateral cooperation with Russia concerning the management and disposal of Russia's surplus weapons-grade plutonium.

[15] FNCA: An international organization aiming to enhance social and economic development through the promotion of peaceful and safe utilization of nuclear technologies among Asian countries. FNCA is composed of 9 countries, including Japan, Australia, China, Indonesia, Korea, Malaysia, Philippines, Thailand and Vietnam.

[16] RCA: An international agreement aiming to facilitate and coordinate cooperative programs concerning research, development and training related to nuclear science and technology for developing countries in the Asia-Pacific region, through authorized organizations in signatory countries, by means of mutual cooperation among signatory countries as well as cooperation with the IAEA, as a part of the IAEA activities. RCA is composed of 17 signatory countries, including Australia, Bangladesh, China, India, Indonesia, Japan, Korea, Malaysia, Mongolia, Myanmar, New Zealand, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Vietnam.

[17] GIF: An international cooperation framework based on an agreement for promoting research and development of the next-generation (the fourth generation) nuclear energy system through international cooperation. GIF is composed of one international organization and 12 countries, including Argentina, Brazil, Canada, China, France, Japan, Korea, Russia, Republic of South Africa, Switzerland, the U.K. and the USA.

[18] GNEP: A scheme that is proposed by the USA aiming for the acceptance of global development and expansion of nuclear power generation as well as ensuring nuclear non-proliferation. The main 6 participants, which are assumed by the USA, include Japan, the USA, France, the U.K., China and Russia.

(Promotion of the use of renewable energy)

Renewable energy, including solar energy, biomass and waste energy, and wind energy, have problems, such as instability of power generation and higher cost, however, since they have advantages, including the potential contribution to addressing global warming and relatively limited resource constraint, it is necessary to actively promote technology development in order to solve the above problems, and thereby, to facilitate its introduction and dissemination.

1) Photovoltaic power generation

Photovoltaic power generation has been spreading as its price has fallen. Nevertheless, development of technologies that further lower costs is essential for the early establishment of a truly independent market. For this purpose, the Ministry of Economy, Trade and Industry is promoting the development of technologies that achieve lower costs and higher levels of efficiency, as well as the development of recycling and reuse technologies.

2) Biomass energy

Based on the Biomass Nippon Strategy (adopted by the Cabinet in March 2006), the Ministry of Internal Affairs and Communications, the Ministry of Education, Culture, Sports, Science and Technology, the Ministry of Agriculture, Forestry and Fisheries, the Ministry of Economy, Trade and Industry, the Ministry of Land, Infrastructure, and Transport, and the Ministry of the Environment are promoting research and development into technologies for the efficient conversion of animal wastes, wood residues, organic sewage, food wastes, and other biomass sources into energy resources.

In particular, concerning biofuel, such as bio-ethanol, a progress schedule toward a drastic expansion of domestic biofuel production aiming to selectively promote the development of technology that can effectively produce ethanol from cellulosic materials, including rice straw and woods, as well as crop resources to be obtained by using abandoned farm land, was prepared in cooperation with relevant ministries, and reported to the prime minister in February 2007.

(Hydrogen energy/Fuel cells)

It is necessary to promote research and development of a fuel cell system that excels in environmental characteristics, allows for utilization of various energy resources, and has potential energy conservation effect in the civilian and transportation sectors, as well as R&D of production, storage and transportation technologies of hydrogen which is used as fuel of the fuel cell system.

In particular, since fuel cells, which directly generate electricity through a chemical reaction between hydrogen and oxygen, are very efficient and emit neither NOx nor SOx, they are expected to be key technology for energy and environmental fields. While the development of fuel cell vehicles and stationary fuel cell systems is well-advanced, there still remain some hurdles to be addressed, such as durability and performance in order to make them commercially feasible. For this reason, the Ministry of Education, Culture, Sports, Science and Technology is promoting the development of innovative new components and materials that can improve fuel cell performance. The Ministry of Economy, Trade and Industry is promoting R&D of elemental technologies of the main unit of the fuel cells, R&D of peripheral technologies, including hydrogen energy utilization technologies, such as the production, transportation and storage of hydrogen fuels, and demonstration of large-scale fuel cell systems for household use, as well as experimental study on fuel-cell-powered vehicles and hydrogen supply system. The Ministry of Land, Infrastructure and Transport, and the Ministry of Environment are conducting demonstration experiments on fuel cells for residential use.

In addition, the Fire and Disaster Management Agency of the Ministry of Internal Affairs and Communications is conducting a study on safety measures that will be needed for installing service equipment in fuelling stations that supplies hydrogen for fuel-cell-powered vehicles as a strategic priority subject in science and technology.

(Promotion of development and utilization of fossil fuels)

1) Petroleum

Since further reduction of environmental burden caused by the use of petroleum is required, the Ministry of Economy, Trade and Industry is promoting the development of technology for higher quality of vehicle fuel, including gasoline and light oil, in order to reduce auto emissions, such as nitrogen oxides and particulates.

In addition, it is becoming important to develop technologies that allows for promotion of energy conservation and resource saving by means of the advancement and improved efficiency of petroleum refineries as well as cooperation with various industries in petrochemical complexes. For this purpose, the Ministry

of Economy, Trade and Industry is developing technologies, including the advancement of heat recovery and promotion of process streamlining in oil factories, and effective utilization of by-products that are produced in petrochemical complexes.

2) Coal

Coal offers excellent supply stability compared to petroleum and other sources. But since coal emits the highest carbon dioxide of all fossil fuels, research and development is needed to reduce its burden on the environment. For this purpose, the Ministry of Economy, Trade and Industry is promoting the development of high efficiency power generation technologies and other clean coal technologies, such as the high-efficiency power generation technologies by the Integrated coal Gasification Combined Cycle (IGCC) and the Integrated coal Gasification Fuel cell Combined Cycle (IGFC).

In addition, research and development of Carbon Dioxide Capture and Storage (CCS) technologies is being conducted from medium- and long-term viewpoints.

3) Natural gas, etc.

Because natural gas has lower carbon dioxide emission and less environmental burden than other fossil fuels, promotion of research and development into its utilization is therefore of importance. Consequently, the Ministry of Economy, Trade and Industry is promoting research into technologies for the manufacture and utilization of liquid fuels (GTL, or Gas-to-Liquid) and dimethyl ethyl (DME), obtained by converting natural gas into liquid fuel, which should lead to the expansion of natural gas use. The ministry is also promoting the research and development of new exploitation technologies for the utilization of methane hydrates, believed to be available as an energy source in relatively large quantities from the seas around Japan.

(2) Promotion of countermeasures for energy conservation

From the viewpoint of preventing global warming and effectively utilizing limited energy resources, it is important to carry out research and development not only to improve efficiency in specific individual devices and element technologies, but also to improve the energy supply and utilization efficiency of all energy systems in society, for example by the introduction and use of distributed systems, and the utilization of unused energy. It is also necessary to promote research and development from a point of view of reducing all energy (life cycle energy) that is directly or indirectly consumed in the process of the production, use, re-use, and disposal of products.

For this purpose, the Ministry of Economy, Trade and Industry has established a strategy for the development of energy conservation technologies aiming to solve the demand-side problems, from discovery to commercialization of a new technology, and thereby to enhance the effectiveness of energy conservation technology development. The ministry is promoting strategic research and development in accordance with the strategy for energy conservation technology, with focus on Super combustion system technologies, Energy utilization technologies beyond time and distance restrictions, Future life environment technologies on energy conservation, Advanced traffic technologies, and New generation device technologies for energy conservation, in order to bring out the synergy effects through mutual cooperation of technology development activities for facilitating technology development.

(3) Others

Issues concerning energy and environment are far-reaching problems that require research from the perspective of natural science and social science. In addition, certain proposals from science academies that can address situations of the post-Kyoto Protocol should be required in the near future for the summit conference that will be held in Japan in 2008. Accordingly, the Science Council of Japan is performing interdisciplinary research by establishing the "Committee on Energy and Global Warming." Moreover, the Science Council of Japan held a symposium with the main subject of energy issues and global warming at the United Nations University in Tokyo in December 2006, with cooperation of the InterAcademy Council (IAC[19]), with a view toward the importance of energy and environment.

Table 3-2-9 shows a summary of the major research topics in the energy sector (excluding nuclear power) implemented during Fiscal 2006.

[19] IAC: The InterAcademy Panel (IAP) on international issues was established in May 2000 in order to fulfill the function of giving scientific advice and recommendations concerning global policy issues. The Holland Royal Academy of Arts and Sciences works for the secretariat, and the Science Council of Japan is a member of the council.

Table 3-2-9 Major research subjects in the non-nuclear energy sector (FY 2006)

Ministry or agency	Research institute or program	Subject
Ministry of Internal Affairs and Communications	Fire and Disaster Management Agency	・Consideration of necessary safety measures for installing an outlet within a gas station that supplies fuel cell vehicles with hydrogen
Ministry of Education, Culture, Sports, Science and Technology	National universities and other institutions	・New energy and energy efficiency R&D ・The Project to Design a Sustainable Management and Recycling System for Biomass and General and Industrial Wastes ・Next-generation fuel cell project
	National Institute for Materials Science	・New century heat-resistant materials project ・Research into the development of highly efficient advanced structural materials with superior processability
Ministry of Economy, Trade and Industry		・Experimental study on fuel cell systems ・Expenditure for commission of advanced scientific research on fuel cells ・Development of solar photovoltaic technology for energy-saving and reduced environmental burden ・Subsidy for development of technology for advanced environmental measures concerning oil fuel ・Demonstration of entrained bed coal gasification power plants ・Photovoltaic power generating technology ・Development of technologies for the stabilization of wind power generating systems ・Biomass energy technologies ・Hydrogen energy technologies ・Fuel cell technologies ・GTL and DME-related technologies ・Development of methane hydrate technologies ・Research and development into clean coal technologies ・Development of energy conservation technologies －Development of fundamental technologies for power electronics, including SiC －Development of basic technologies for next-generation semiconductors －Development of technology for environment-conscious chemical process using high-efficiency oxidation catalyst －Development of basic technology for creating environment-conscious ultrafine grain steel －Development of elemental technology for high-efficiency turbine commercialization －Research and development for CO_2 heat pump water heater with higher efficiency and reduced size －Research and development into high-efficiency organic EL technology ・Development of technology for distributed energy network systems ・Development of technology for performing the comprehensive evaluation of energy systems ・Development of technologies for sequestration and effective use of carbon dioxide
	Advanced Industrial Science and Technology	・Technologies for distributed energy network systems ・Clean diesel technologies

Ministry or agency	Research institute or program	Subject
Ministry of Economy, Trade and Industry	New Energy and Industrial Technology Development Organization	・Development of technologies for new use pattern of fuel cells ・Large-scale demonstration works for stationary fuel cell systems ・Strategic technology development for commercialization of polymer electrolyte fuel cell ・Maintenance project for building common infrastructure of hydrogen society ・Development of basic technology for the safe use of hydrogen ・Development of technologies for solid oxide fuel cell systems ・Basic research project for advanced hydrogen science ・Development of technologies for electric storage systems for smooth power system interconnection ・Research and development of future technologies for solar photovoltaic systems ・Field test project for new technologies of solar photovoltaic power generation ・Experimental study on new electric power network systems ・Research and development of basic technologies for application of superconductivity ・Strategic development of technology for streamlined energy use
	Japan Oil, Gas and Metals National Corporation	・Promotion of development and utilization of oil and natural gas
Ministry of Land, Infrastructure and Transport		・Development of high-efficiency fuel cell systems for collective housing ・Development of a new energy system to reduce CO_2 emissions, as well as the development of optimization technologies to adapt the system to houses and buildings ・R&D on the evaluation of positive effects on the urban environment from adding greenery to building sites ・Research on technology for improving effective energy conservation performance in buildings and its application method to existing stock
	Port and Airport Research Institute	・Research on understandings of coastal and offshore wind condition characteristics as well as utilization of wind energy ・Research on wave-power generation in sea area around port
Ministry of the Environment	Technology development works to prevent global warming	・Project of Establishing Green-Hydrogen, Based Society in Honjo-Waseda Area ・Development of technologies for local eco-energy web systems (a method for controlling mutual energy utilization system with focus on natural energy) ・Technologies for energy conservation by means of multisource heat supply using low-temperature exhaust heat (heat transport technology using the PCM) ・Development of technology for production of woody biocoke using the pyrocoking technology as well as a system for application of SOFC to power generation

3.2.2.6 MONODZUKURI Technology

The manufacturing industry (MONODZUKURI) is the industry with the highest international competitiveness among all industries, and is a lifeline for Japan. It also has a large ripple effect on other industries and serves as a driving force for economic growth.

In the Third Science and Technology Basic Plan, it is promoted with the name changed from "manufacturing technology" to "MONODZUKURI technology," in order to clearly show the viewpoint that it is strengthening the ability of value-creating MONODZUKURI, which aims for the development of science and technology that raises the value of "things (*mono*)" by stepping out of the conventional framework of manufacturing technology.

(1) Promotion of MONODZUKURI technology with a common basis

As strategically focused science and technology, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) is promoting the development of the world's first "only one, number one" measurement analysis technology and device that are able to respond to needs from the world's most advanced researchers.

The Ministry of Economy, Trade and Industry (METI) is implementing the development of a common basis for new generation robots and the development of RT (robot technology) systems to achieve missions in accordance with the Strategic Technology Roadmap.

(Support for the advancement of core manufacturing technologies at SMEs)

It is Japanese SMEs, whose excellent technologies play key roles in production, including casting, forging and plating, who work closely on details with downstream companies in the course of developing and manufacturing products and parts, that allow Japanese manufacturing to be internationally competitive. In order to strengthen that competitiveness in manufacturing areas including fuel cells, robots and other high-tech industries that are taking the lead in the Japanese economy, as well as to foster the creation of new industries, it is important to further enhance the competitiveness of SMEs with important core technologies.

Those SMEs are, however, facing various difficulties, including changes in their business ties and connections as competition becoming more severe, greater risks in their technological development due to increased sophistication and specialization, difficulty in securing human and financial resources, etc. To this end, based on the "Law Concerning the Enhancement of Fundamental Technology for SME Creativity" promulgated in April 2006, METI implemented strategic and focused measures such as the promotion of information-sharing between upstream and downstream industries and support for research and development on core technologies.

1) Support for research and development by manufacturing SMEs

Under the SME Technological Advancement Law, specific core technologies (casting, forging, plating, pressing, die making, etc.) were designated, and for each, "guidelines for advancement of specific manufacturing core technologies" were issued, to present future "visions" that individual SMEs can aim to achieve in their development of their technologies. The government also approved specific research and development plans, etc., which SMEs prepare based on the guidelines, and supported them.

Efforts by SMEs to undertake innovative, highly risky research and development, research and development to realize innovation in production processes, etc., were supported. Furthermore, certain costs for patents on the results of research and development by SMEs, under specific research and development plans, etc., approved by the government, were reduced or waived. Moreover, special loans to SMEs were provided by enterprises (JASME), and limits for credit insurance were expanded.

2) Enhancement of the environment for advancement of manufacturing core technologies

Support was provided for activities to allocate personnel who can work between SMEs in the upstream playing key roles in core technologies and downstream companies engaged in production, for example, of fuel cells and information home appliances with the aim of coordinating and fine-tuning their cooperation, to create opportunities for information exchanges and matching, and to create opportunities for SMEs and large businesses to interact with each other.

In order to objectively establish the accuracy and reliability of processing and manufacturing by SMEs and to support the commercialization of their products in the market, a system to manage technical accuracy, etc., of SMEs using examination and inspection organizations, etc., human resources and facilities was developed. In that way, the basis for measurement standards was enhanced toward establishment of a traceable system essential for global business development.

Furthermore, very versatile software has been developed so that individual workers' tacit knowledge, including design and processing know-how, owned by manufacturing SMEs, can be stored digitally in a systematic way. At the same time, in order for SME manufacturers without experience in designing software to create business software (production management, quality control, shipment management, etc.) and utilize accumulated know-how, etc., in their production activities, tools to support creation of such software ware developed and provided to the SMEs. In this way, continuation of core technologies owned by SMEs was supported.

Serving as "shelters" for SMEs with problems involving intellectual property, societies of commerce and industry and chambers of commerce and industry across the country served as one-stop access points for advice and consultation. Seminars on prevailing corporate activities focused on intellectual property also were staged in various places around the country.

(2) Promotion of MONODZUKURI technology with which groundbreaking and dramatic development is expected

METI is implementing the "Highly Integrated, Complex MEMS Project" and the "MEMS Design and Analysis Support System Development Project," which aim for the maintenance and strengthening of international competitiveness of small-sized,

high-precision, highly energy saving and high-performance key devices in various areas including information and communication, medical care/biotechnology, automobiles, robots, aerospace and welfare, by establishing manufacturing technology for microelectromechanical systems (MEMS).

(3) Development, utilization of human resources and inheritance and deepening of skills among them

The advantage of MONODZUKURI in our country is in the excellence of engineers and skilled workers at the actual worksites. However, with the "2007 problem," which refers to a large number of baby-boomers reaching retiring age, decline of MONODZUKURI human resources in terms of both quality and quantity is a concern.

In order to promote the MONODZUKURI technology field in the future, it is essential to develop creative human resources who support the technology. Various efforts are made in the area of school education and lifelong learning.

In primary and secondary education, based on the Courses of Study, education concerning MONODZUKURI within the relevant subjects is provided from the elementary school stage. In particular, because specialized upper secondary schools including industrial high schools are serving an important role in the development of MONODZUKURI human resources in Japan, further enhanced efforts are being made in their area including the "Aspire to be a Specialist!" project, implemented from Fiscal 2003, to focus on education incorporating advanced technologies and skills in specialized upper secondary schools.

Activities such as experiencing actual workplace in lower secondary schools and internship in upper secondary schools evokes a willingness to learn among students, and will foster visions for labor and vocation. It is also a valuable opportunity for the students to learn knowledge and skills actually used in the workplace, including offices for manufacturing. These activities are therefore actively promoted by various facilities.

For higher education, practical education to support MONODZUKURI is being implemented in each college and university. At the same time, it is aimed to improve the training of professionals with advanced specialized skills at professional schools in terms of both quality and quantity.

Colleges of technology aim to become an attractive option, by conveying their appeal to manufacturing through approaches such as the "All-Japan Colleges of Technology Robot Contest." They also hold public lectures and experience classes targeted at people in the local community and elementary and junior high school students.

In special training colleges, the fostering of human resources for manufacturing is promoted through practical vocational education and specialized skill education. The special training colleges are also engaged in the "Program to Support Independence and Challenges by Young People Using Special Training Colleges," which develops short-term education programs utilizing special training colleges, in order to improve the capabilities of those who aim to become a permanent employee but cannot, such as part-time workers.

In the area of lifelong learning, opportunities for career improvement are being amplified through the acceptance of working people at universities and other schools or public lectures. It is also intended to foster human resources for manufacturing by providing children opportunities to experience and learn manufacturing in each region, through approaches such as utilizing citizens' public halls and museums or opening classes in educational institutes to the public.

In addition, in order to support engineers to extensively learn the basic knowledge of and knowledge on failures in science and technology, the Internet educational tool for self-learning (http://weblearningplaza.jst.go.jp/) which covers each area of science and technology as well as across different areas in an interdisciplinary manner, and a database that includes failure cases in the field of science and technology (http://shippai.jst.go.jp/) are provided. As of the end of March 2007, the educational tool for self-learning offers 727 lessons, and the failure cases included account for 1,136.

The major research topics in Fiscal 2006 for MONODZUKURI are as shown in Table 3-2-10.

Table 3-2-10 Major research topics for MONODZUKURI technology field (FY2006)

Ministry or agency	Research institute or program	Subject
MEXT	Japan Science and Technology Agency	・Project for the development of advanced measurement analysis technology and device
	Institute of Physical and Chemical Research (RIKEN)	・Research on the establishment of technology information integration system in advanced IT
METI	New Energy and Industrial Technology Development Organization	・Highly Integrated, Complex MEMS Project ・Research and development on ultra-flexible display members ・Next-generation lightwave control material and technology on elements ・Technology for highly efficient manufacturing of three-dimensional optical device

3.2.2.7 Infrastructure

Infrastructure is a basic sector that supports people's lives. In order to achieve a prosperous, secure, safe, and comfortable society, research and development is promoted to reduce the risks inherent in society, and to improve the people's conveniences so they can achieve a quality life.

(1) The world's safest country

(Disaster prevention)

In order to mitigate the potential damage from natural disasters, it is important to be able to fully utilize scientific and technical knowledge to prevent disasters before they happen, limit the spread of damage when disasters actually occur, and recover from disasters.

Earthquake research in Japan is promoted with close collaboration and cooperation between relative administrative agencies, under policies such as the "Comprehensive and basic policy (April 1999)," and the "Survey and Observation Plans" formulated by the Headquarters for Earthquake Research Promotion (Director: Minister of Education, Culture, Sports, Science and Technology), which is an organization established based on the Special Measure Law on Earthquake Disaster Prevention enacted in 1995. Based on the result of evaluation on 98 major fault zones in Japan, the Headquarters for Earthquake Research Promotion published the revised edition of the "National Seismic Hazard Maps for Japan" in September 2006 (Refer to Column 3, 1.1.3).

In addition, research and development in relation to disaster prevention science and technology is being promoted by the National Research Institute for Earth Science and Disaster Prevention (NIED), based on the "Research and Development Policy on Disaster Reduction" formulated by the Council for Science and Technology Subdivision on R&D Planning and Evaluation in July 2006. Research on the prediction of earthquake and volcanic eruption is carried out in a comprehensive and systematic manner with the cooperation of relevant organizations including universities, based on the "Second New Observation and Research Plan for Earthquake Prediction" and the "Seventh Plan for Volcanic Eruption Prediction" (both Fiscal 2004-2008) established by the Council for Science and Technology.

Research on earthquake observation, monitoring and prediction is one of the essential R&D issues. Based on the policy of the Headquarters for Earthquake Research Promotion, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) promotes Strategic Prioritized Science and Technology including focused survey and observation of earthquakes off Miyagi Prefecture and the fault zone on the Itoigawa-Shizuoka geotectonic line, research on subduction zone earthquakes such as the Tonankai and Nankai Earthquakes, development of dense ocean-floor network system for Earthquakes and Tsunamis in order to lay an observation and monitoring system with seismometers, water pressure gauges and other instruments on predicted seismogenic zones of the Tonankai Earthquake, and the Special Project for Earthquake Disaster Mitigation in Urban Areas, which aims to establish a science and technology basis that significantly reduces human and physical damages when major earthquakes hit large cities. In addition, the Ministry promotes research and development for essential R&D issues, including additional and supplemental surveys on 98 major fault zones in Japan.

As for technologies to alleviate damages such as

improving earthquake-resistance strength and upgrading disaster reaction, rehabilitation and restoration plans, NIED is implementing experiments and research on earthquake resistance using a three-dimensional full-scale earthquake testing facility (called "E-Defense"), in order to obtain knowledge on secular distortion, the effect of antiseismic reinforcement and input loss related to the destructive process of steelwork and bridgework.

As for technologies to observe, forecast and reduce disasters by wind, flood, landslide and snow, technologies, as well as technologies to predict volcanic eruption, NIED is implementing research on the prediction of the occurrence of landslide, wind and flood disasters using MP radar, research related to the practical use of a system to predict snow and ice damage occurrence and disaster prevention based on the system, as well as research related to the prediction of volcanic eruption and volcanic disaster prevention.

Technology on the observation and monitoring of natural disasters by satellites is positioned as strategically focused science and technology. The operation of the Advanced Land Observing Satellite "DAICHI" (ALOS), launched in January 2006 for the objective of mapping and disaster monitoring, and research and development of high-precision positioning, navigation and timing experimental technology using a quasi-zenith satellite system are being implemented. These technologies are being developed and operated as technologies comprising the Key Technologies of National Importance, "Earth Observation and Ocean Exploration System," aiming for domestic and international contribution by establishing a global observation and monitoring system using satellites, which is essential for the overall security of Japan.

Furthermore, "Research on the Unraveling of the Development Mechanism of Windstorm, Tornado and Flood Associated with Typhoon No.13 in 2006 and Countermeasures" and "Research Related to the Severe Disaster Caused by the Tornado in Saroma Town, Hokkaido" are being implemented with Grants-in-Aid for Scientific Research, under the cooperation of relevant Ministries and Agencies as well as universities.

In the area of international cooperation, Japan is taking part in bilateral research on science and technology for disaster prevention within the framework of science and technology cooperation agreements with the United States, Russia, Italy, and others, and the "U.S.-Japan Cooperative Program in Natural Resources" (UJNR).

The Fire and Disaster Management Agency is promoting research and development related to fire prevention such as research on ensuring the safety of facilities handling hazardous materials when earthquakes occur, technology to reduce the damage of disaster, and research on technologies for disaster countermeasures.

In this sector, a number of documents have established priorities for the promotion of research and development, including the "Basic Plan for the Ministry of Land, Infrastructure and Transport Technology," adopted in November 2003 by the Ministry of Land, Infrastructure, and Transport, the "Basic Plan for Research and Development in Information and Telecommunications," adopted in February 2000 by the Ministry of Posts and Telecommunications' Council for Telecommunications Technology.

In specific, research and development related to comprehensive land use such as land management technology utilizing cutting-edge technologies are being promoted by the Ministry of Land, Infrastructure and Transport (MLIT).

The Geographical Survey Institute (GSI) operates 1,233 (as of March 2007) GPS stations throughout the nation and other advanced survey technologies, such as Very Long Baseline Interferometry (VLBI), to survey and monitor crustal deformation and plate motion.

The Japan Meteorological Agency (JMA) establishes and operates observation facilities, while providing earthquake information with centralized observation data including other relevant institutes.

The agency is also working together with NIED to conduct research and development towards practical application of the emergency earthquake information reports (EEIR), which aim to provide information including the hypocenter and magnitude of an earthquake before the strong motion occurs in order to mitigate the earthquake's damage.

The Japan Coast Guard promotes seafloor geodetic observation, bathymetric survey and the research for the evaluation of earthquake activities.

In addition to the above, the Science Council of Japan, established the "Committee for the Creation of Safe and Secure Society against Global Natural Disasters," in response to an inquiry from the Minister of Land, Infrastructure and Transport, based on the recent increase of serious disasters on a global scale such as earthquakes, tsunamis, typhoons and hurricanes, and changes in the social environment such as increase in people vulnerable to disasters due to the aging society. The committee is implementing the prediction of disaster due to climate change and analysis on the social mechanism of earthquake disaster.

(Antiterrorism and public safety measures)

In recent social conditions where international terrorism acts are aggravated, and deterioration of public safety is pointed out, to realize safe society with less crime is one of the most important and urgent needs of the general public. Therefore, it is quite important to further enhance approaches utilizing the most advanced science and technology for antiterrorism and public safety measures.

It is critical for antiterrorism to promptly detect hazardous and dangerous materials at the site in advance. In particular, Japan has fundamental technology to detect substances. Because developing this technology into practical use ahead of the rest of the world will not only promote antiterrorism measures but also will contribute in taking the initiative in terms of global standards, it is necessary to focus on such projects and to actively promote them. To this end, the National Police Agency and MEXT utilize the competitive funding system to implement research and development on devices to promptly detect explosive materials, biological agents and chemical agents on-site and to dispose of them safely.

In order to realize society with less crime with limited human resources, it is required in the area of crime countermeasures to intensively promote the development of technologies and systems that can be used at the site of crime prevention, investigation support and identification. Therefore, the National Police Agency is implementing research and development related to a system with functions to automatically record the methods of unauthorized computer access that were actually used on computers, crime prevention and investigation support based on behavioral science, the development of identification and testing methods using the latest information processing technology, personal forensic examination on using three-dimensional facial imagery, DNA profiling, substance identification technology for the identification of poisonous materials and trace evidence, and technology to ensure children's safety at school and on the route to and from school.

(Transportation and transit systems)

There is an urgent need to restore the safety and reliability of the means of transportation, which are transportation devices necessary for everyday life of the general public. It is necessary to intensively promote the utilization of new technology to thoroughly prevent accidents and ensure safety by considering the expected demand increase in air transportation in the future as well as human factors such as operators at transportation facilities, and "finding," "decision" and "operation" of car drivers.

The National Police Agency and MLIT are implementing research and development in relation to a system to support safe driving through coordination with infrastructure, and information processing capacity relevant to safe driving..

In addition, the Ministry and Agency are working with advanced research and development towards the realization of more safe and comfortable transportation and transit systems in the future.

MLIT provides subsidies to the Railway Technical Research Institute in order to promote research and development for the practical use of the superconducting magnetically-elevated train, which is targeted for high speed transportation in the future. In addition, it is promoting technology with high versatility for cross-sectional needs among deep subterranean utilization businesses, based on the "Vision of Research and Development Regarding the Deep Subterranean Utilization."

In addition, as for air transportation system, which is one critical social infrastructure for modern lifestyle, it is expected not only to support the maintenance and improvement of safety and environmental compatibility, but also to have ripple effects on a wide range of areas including information and telecommunication, nanotechnology and materials.

MEXT will implement research and development based on the "Promotion Policy for Research and Development into Aerospace Science and Technology," formulated in July 2006 by the Council for Science and Technology Subdivision on R&D Planning and Evaluation. The Ministry is currently promoting technology to prevent accidents and ensure safety of transportation and technology for the domestic production of aircrafts to respond to new demands, which are both selected as strategically focused science and technology, under the three keywords of "from elements to integration," "safety and efficiency" and "supersonic velocity." As for "from elements to integration," the Ministry is making contribution such as providing advanced technology and test facilities for engine development towards the domestic production of passenger aircraft, which will be the first in 40 years since the production of YS-11. The contribution is bringing successful results, such as leading the world in manufacturing large structure models with low-cost composite. With "safety and efficiency," in order to cope with increase in the number of operations, the

Ministry is implementing research and development of the next generation operation system, which improves safety and efficiency. In the project, it achieved the world's first success in flight demonstration of decentralized, high-density operation. With "supersonic velocity," it is implementing research and development aimed for obtaining advantageous technology in leading the world, such as technology to solve sonic boom which is a bottleneck in the realization of supersonic passenger aircraft, by developing the technology obtained through flight experiments of small-sized supersonic prototypes. Other than the above, the Ministry is focusing its effort in research and development of rotocraft technology and technologies for futuristic aircraft such as vertical takeoff and landing (VTOL) aircraft and non-fossil fuel aircraft.

The Ministry of Economy, Trade and Industry (METI) is discussing the policy for aircraft industry, including the international joint development of commercial aircrafts and engines, in the Aircraft Industry Subcommittee, Aircraft and Space Industry Committee, Industrial Structure Council. Also, in relation to the technology for the domestically developed aircraft which meet new demands selected as strategically focused science and technology, the Ministry is promoting research and development on Environmentally-friendly, High-performance Small Aircraft and Environmentally-friendly, Small Aircraft Engine, to demonstrate the integration technology for small aircrafts and engines that are low-cost and have small effects on the environment, and the development of technologies for manufacturing and processing next-generation structural parts and materials, which realize lower cost and higher reliability of composite materials and magnesium alloy parts and materials for aircrafts. The Ministry also conducts research and development of elemental technologies and configuration studies necessary for the practical application of supersonic transport aircraft that are highly economical and compatible with the environment, as well as the development of technology related to next generation accessories such as the electric control system and electric air conditioning system.

The Electronic Navigation Research Institute, under MLIT, is implementing research on telecommunications, navigation, monitoring and air traffic management as technologies to ensure and facilitate the safety of air traffic. It is expected that this research will play an important role in the development of air transportation in the future.

The major research topics in Fiscal 2006 for infrastructure are as shown in Table 3-2-11.

Table 3-2-11 Major research subjects in the infrastructure sector (FY2006)

Ministry or agency	Research institute or program	Subject
National Police Agency	National Research Institute of Police Science	・Research on cognitive capacity relevant to safe driving ・Research on the improvement of individual identification utilizing three-dimensional facial imaging ・Research on speaker recognition techniques adequate for new speech communication methods
Ministry of Internal Affairs and Communications	Fire and Disaster Management Agency	・Development of rational method compatible with technology standards for facilities handling hazardous materials related to “slightly long-period ground motion” ・Development and preparation for introduction of evaluation methods for corrosion and deterioration of facilities handling hazardous materials ・Practical use of information systems to support activities in underground space where firefighting operation is difficult
	National Research Institute of Fire and Disaster	・Research on fire security in congested city space ・Research on firefighting operation at the time of large-scale natural disaster ・Research on security against special kinds of disaster ・Research on firefighting and the prevention of fire and explosion of chemical substances ・Research on improving the safety of facilities handling hazardous materials

Ministry or agency	Research institute or program	Subject
Ministry of Education, Culture, Sports, Science and Technology	Research and Development Bureau	・Promotion of seismic investigation and research ・Development of Dense Ocean-floor Network System for Earthquakes and Tsunamis ・Special project for Earthquake Disaster Mitigation in Urban Areas ・Investigative research on ocean-trench earthquakes including Tonankai and Nankai Earthquakes
	Japan Science and Technology Agency	・Advanced integrated sensing technology
	RIKEN	・Development of a Supersensitive Poison Sensor Using a Nanostructure Film
	National Research Institute for Earth Science and Disaster Prevention	・Research project for crustal activity based on seismic data ・Earthquake engineering research utilizing the Three-Dimensional Full Scale Earthquake Testing Facility (E-Defense) ・Formulation of Japan seismic hazard information station ・Research into volcanic eruption prediction and disaster mitigation ・Research project for developing a snow disaster forecasting system and snow hazard maps ・Prediction of landslides and urban floods using Multi-Parameter Radar ・Research project on disaster risk governance ・Program to support disaster prevention information infrastructure ・Frontier research for earthquake disaster mitigation
	Japan Agency for Marine-Earth Science and Technology	・Research on prediction technology for typhoon s and other local and notable phenomenon through simulation
	Japan Aerospace Exploration Agency	・Operation of the Advanced Land Observing Satellite “DAICHI” (ALOS) ・High-precision positioning, navigation and timing experimental technology using a quasi-zenith satellite system ・Research into aviation safety and environment protection technologies ・Technologies for higher performance domestic passenger aircraft
	Special Coordination Funds for Promoting Science and Technology	・Development of Non-invasive Detection Techniques for Illegal and Dangerous Substances by Using Terahertz Waves ・Underwater security sonar system ・Development of integration system of detection and treatment of explosives for anti-terrorism act ・Development of simultaneous on-site detection methods for chemical agents and biological toxins ・Development of effective decontamination methods in chemical and biological terrorism
Ministry of Health, Labour and Welfare	National Institute of Occupational Safety and Health	・Resolving the destabilizing factors during the building of bridges and the development of safe construction technology ・Research on the prevention of explosion/fire due to static electricity at the time of hydraulic spraying ・Research on the basic safety of human-machine cooperative operation systems ・Research on the improvement and practical use of risk management technology in accident-prone areas

Ministry or agency	Research institute or program	Subject
Ministry of Economy, Trade and Industry	National Institute of Advanced Industrial Science and Technology	・Research on seismogenic mechanism and prediction at active faults ・Research on the diversity of ocean-trench earthquakes and the improvement of prediction thereof ・Research on the improvement of earthquake disaster prediction based on information on active faults and geological conditions
	New Energy and Industrial Technology Development Organization	・Project on environmentally-compatible, high-performance small aircraft ・R&D on an engine for environmentally-compatible small aircrafts
Ministry of Land, Infrastructure and Transport	Policy Bureau	・Research and development on next-generation inspection technologies to strengthen terrorism countermeasures for public transport
	Subsidy for the development of railway technologies	・Development of a superconducting magnetically levitated train
	National Institute for Land and Infrastructure Management	・Study for mitigation of disaster caused by large-scale earthquakes and tsunamis ・Review on earthquake disaster prevention utilizing earthquake safety evaluation technology ・Evaluation method of countermeasures with various utilities against infrequent mega-risk type coastal hazards ・Research on water management method utilizing precipitation prediction information ・Development of multi-platform for emergency information transmission targeted to those who need support at the time of disaster ・Research on desirable environment formed by buildings in urbanized society ・Development of effective evaluation and management methods for cost reduction of public works ・Development of technologies enabling a reasonable level of revitalization and utilization of aged buildings in view of their historical and cultural value ・Development of techniques for revitalizing and reorganizing suburban residential districts in view of Japan's expected population decline ・Research on the method for evaluating the level of social infrastructure development ・Research on procedure of cost reduction and safety operation for airports by preventive maintenance system ・Study about an effective use policy of an area along the shore by AIS information
Ministry of Land, Infrastructure and Transport	National Institute for Land and Infrastructure Management	・Research on the appropriate management method of sewer culvert ・Research on a method of LRT utilization for the urban revitalization of local cities ・Research on performance indication and certification system of building materials for the further promotion of the performance prescription of building standards ・Study on the integrated risk management of the infrastructure for international traffic network ・Research of road environment to contribute to prevent human errors ・Research on the evaluation/countermeasure technologies for ensuring the safety of users' living activities in architectural space

Ministry or agency	Research institute or program	Subject
	Geographical Survey Institute	・Research on the characteristics of the crustal movement near the source areas for the subduction earthquakes along the Japan Trench and the Chishima Trench ・Research on the optimization of observation network for volcanic deformation and monitoring ・Research on ship budget on the subducting plate boundary along the Kuril Trench estimated from geodetic data ・Precise geodetic network survey ・Crustal deformation survey ・Very long baseline interferometry (VLBI) ・Gravity survey and geomagnetic survey ・Research on the advanced utilization of time-series geographic information on national land ・RFID-based positioning systems for enhancing safety and sense of security
	Public Works Research Institute	・Anti-seismic technology for roads and river facilities to prepare for major earthquakes ・Research on the prevention and alleviation of flood damage worldwide through comprehensive flood risk management ・Development of technology for the qualitative improvement of river levees for improving flood control safety ・Development of technologies for predicting the danger of landslide disaster caused by heavy rain and earthquake and alleviating damages thereof ・Research on the improvement of disaster prevention standards for roads compatible with large-scale rockslide, slope failure, etc. ・Research on the improvement of design method for the effective development of road infrastructure ・Research on the improvement of maintenance study for road constructions ・Research on the durability of civil engineering facilities in cold regions
Ministry of Land, Infrastructure and Transport	Public Works Research Institute	・Research on the improvement of safety and efficiency of winter roads ・Research on the improvement of the water distribution function and preservation of the structural function of farm irrigation facilities in snowy cold regions
	Building Research Institute	・Development of anti-seismic improvement technology for general use aimed for increase in the rate of facilities with anti-seismic reinforcement ・Development of functional fire-safe design methods based on fire risk evaluation ・Development of technology to support disaster countermeasures to promote disaster-resistant urban development ・Development of technology to prevent the damage of nonstructural materials that were exposed to earthquakes or strong wind disasters ・Technology development to improve daily safety and assurance of housings and living environment ・Research on methods to recycle/utilize existing construction stocks ・Research on methods to reorganize cities/living space compatible with the depopulating society
	Japan Meteorological Agency	・Earthquake observation network, earthquake and tsunami monitoring system, etc. ・Monitoring systems at Tokai Region, etc. ・Unification of seismic data on relevant organizations ・Volcanic observation

Ministry or agency	Research institute or program	Subject
	Meteorological Research Institute	・Research on the improvement of the prediction accuracy for Tokai Earthquake and the process towards the occurrence of Tonankai/Nankai Earthquakes ・Research on the advanced usage of earthquake/crustal movement observation data ・Research on the development of technology to understand magma activity quantitatively and improvement of the judgment of volcanic activity based on it ・Research on the upgrading of non-hydrostatic model (NHM) and the improvement of assimilating technology ・Research on the technology to judge the danger of severe weather ・Research on the process of the structural change of typhoons that hit the land and the occurrence of storm wind, heavy rain and tidal waves that accompany it
Public Works Research Institute	Hydrographic and Oceanographic Department, Japan Coast Guard	・Observations for the elucidation of crustal activities leading up to earthquake generation ・Observations for precise monitoring of crustal activities ・Promotion of marine geodesy
	National Maritime Research Institute	・Research for the development of foundation technology necessary for realizing highly-efficient maritime distribution system conducive to the promotion of modal shift ・Research for the establishment of risk-based safety evaluation methods to clarify the safety standards with which ships should comply ・Research for the establishment of methods to analyze the causes of ship accidents under heavy weather where unusual waves occur and the improvement of safety ・Research on the improvement of ship security against unlawful acts such as acts of terrorism
	Port and Airport Research Institute	・Development of performance design methods in countermeasures for long-period waves ・Research on wave prediction methods assimilating wave observation data ・Research on disaster prevention technology against tsunamis caused by ocean-trench earthquakes ・Real-time monitoring of tsunamis utilizing the nationwide development of a GPS wave gauge and the existing wave observation network, as well as the development of prediction systems ・Research on the prediction of tidal wave damage and countermeasures thereof compatible with the increase in scale and severity of typhoons in line with global warming ・Development of technology to reproduce tsunami and tidal wave damages
	Electronic Navigation Research Institute	・Research on airspace safety evaluation for the introduction of RNAV route ・Research on conflict detection methods utilizing information on the dynamic state of aircrafts ・Research on human factor evaluation and analysis methods in air traffic control
	National Institute for Sea Training	・Research on human errors in maritime collisions
	Marine Technical College	・Basic research on the cutting of mooring cable at the fair-leader part ・Detection of abnormal leakage of machinery, equipment and plants

3.2.2.8 Frontier Science

Frontier science is an area to explore and probe the unknown in space and the oceans, and to promote R&D for the development and use as a new area for utilization. In the Third Science and Technology Basic Plan, frontier science is positioned as an area where R&D should be promoted, focusing on R&D issues that must be addressed by the nation. This area aims to contribute to improvement in the safety and security of people's lives, the quality of people's lives, development of economic society, the overall security of Japan, and sustainable development of human beings, by using communication satellites and positioning, navigation and timing systems, earth observation and monitoring systems, and the oceans which have abundant resources.

(1) Space development and utilization

Space development and utilization expands universal knowledge regarding the origin of the universe and various phenomena on earth, and contributes largely in improving the quality of people's lives and development of industries. In addition, space technology is a strategic technology that is closely related to national security in a broad sense, and also it is a very important technology area that is related to the international status of Japan.

Since the first satellite "OHSUMI" launched in 1970, 119 satellites have been launched by the end of March 2007. The launch plans of major satellites in Japan in the future are shown in the Table 3-2-12.

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) directed the Japan Aerospace Exploration Agency (JAXA) to promote research and development in a strategic and concentrated way in accordance with the "Long-Term Plan for Space Activities" in September 2003, based on discussion in the Space Activities Commission. The launches of H-IIA launch vehicles and M-V launch vehicles have been successfully accomplished for nine consecutive times before the end of March 2007, starting from the launch of H-IIA Launch Vehicle No.7 in February 2005. As for space science research projects, the solar observation satellite "HINODE" (SOLAR-B) has also achieved successful results. Japan has continuously achieved significant advances as one of the leading countries of space technology in the world.

Table 3-2-12 The table of satellites planned to be launched

Satellite	Weight (kg)	Orbital altitude (km)	Launch vehicle	Launch date (fiscal year)	Major objectives
Japanese Experiment Module of the International Space Station (JEM; also known as “Kibo”)	Approx. 26,800	Approx. 400	U.S. Space Shuttle	2007, 2008	Expansion of Japan's space activities, promotion of leading science and technology development, and contribution to the advancement of international cooperation
SELenological and Engineering Explorer (SELENE)	Approx. 2,900	Orbit around the moon (Approx. 100)	H-IIA	2007	To research the origin and evolution of the moon, and to collect data for surveying feasibility of the utilization of the moon, etc.
Wideband Internetworking engineering test and Demonstration Satellite (WINDS)	Approx. 2,700	Geostationary orbit	H-IIA	2007	Development, experiment, and demonstration of the ultra-high speed and wideband communication technology of the satellite
Greenhouse Gases Observing Satellite (GOSAT)	Approx. 1,750	Sun synchronous orbit Approx. 666	H-IIA	2008	Continuous observation of greenhouse gases, to contribute to the elucidation and forecast of global warming, climate change, etc.
H-II Transfer Vehicle (HTV)	Maximum supply weight: Approx. 6,000	(Approx. 350-460)	H-IIB	2009	To supply materials to the International Space Station by the Japanese transport system
Quasi Zenith Satellite System (QZSS)	Approx. 1,800	Quasi-zenith orbit (Long radius of the orbit: Approx. 42,000)	H-IIA	2009 (planned)	To demonstrate the fundamental technology of positioning, navigation and timing systems using satellites, which reinforces the global positioning system
24th scientific satellite (PLANET-C)	Approx. 480	Orbit around Venus (Approx. 300-80,000)	H-IIA	2010	To explore Venusian atmosphere, and solve riddles in the basic principles of planetary weather and the evolution of atmospheres
Global Change Observation Mission - Water (GCOM-W)	Approx. 1,800	Sun synchronous orbit Approx. 700	H-IIA	2011	To implement observation on a mass global scale that will be effective for ascertaining the global water circulation system
25th scientific satellite (ASTRO-G)	Approx. 910	Highly elliptical orbit (Approx. 100-20,000)	(Unknown)	2012	To describe the center of galaxies and areas appearing newborn stars with the highest resolution, and resolve the physical conditions
Global Precipitation Measurement/Dual-frequency Precipitation Radar (GPM/DPR)	Approx. 3,000	Approx. 400	H-IIA (still in the process of planning)	2013	To develop the Dual-frequency Precipitation Radar (DPR) for monitoring 3-dimensional structure of rainfall, as part of international cooperation in the Global Precipitation Measurement (GPM) Program
Mercury Exploration Project (Bepi –Colombo)	220 (MMO)	Elliptical polar orbit around Mercury (Approx. 00-12,000) (MMO)	Soyuz Fregat 2B	2013	To observe the magnetic field, magnetosphere, the inside and the surface of mercury from many angles through international cooperation with the ESA (European Space Agency). Japan is in charge of the Mercury Magnetospheric Orbiter (MMO).

Note: The launch dates above are as of March 2007 and could be changed in the future.

(Space transportation system technology)

In order to maintain Japan's overall security and autonomy in international society, it is important to have the ability to transport necessary satellites to a given place in space by the nation itself. Also, because space transportation system technology is an advanced system technology, the activities themselves for improving technical capabilities sophisticate the industry and develop the social economy. Therefore, "space transportation system technology" is selected as an essential R&D issue.

In particular, the development, manufacturing and launch of H-IIA launch vehicles, H-IIB launch vehicles (an upgraded version of the H-IIA launch vehicle), H-II transfer vehicles (HTV) and GX launch vehicles, implemented by JAXA, are positioned as one of the strategically focused science and technology, named "highly reliable space transportation system technology." The H-IIA launch vehicle is the central rocket in Japan's space program, with the capability to launch a large-sized satellite. In Fiscal 2006, H-IIA No.10 launched optical-type IGS (Information Gathering Satellites) No.2, H-IIA No.11 launched the Engineering Test Satellite VIII "KIKU No.8"(ETS-VIII), and H-IIA No.12 launched radar-type IGS No.2 and demonstration satellite for optical-type IGS No.3. Due to these launches, the success rate of H-IIA launch vehicles achieved more than 90%, which is significantly higher than the world standard at the early stage of operations. Also, in order to launch the HTV, development projects of H-IIB launch vehicles are under way, which have the capability to transport eight-ton class satellites to geostationary transfer orbit. Also, development projects of HTV, which should contribute in the International Space Station (ISS) project of Japan by transporting foods, commodities and research materials to ISS are under way. The test vehicles of H-IIB launch vehicles and technology demonstration vehicles of HTV will be launched in Fiscal 2009. Development, manufacturing and launch of these H-IIA launch vehicles, H-IIB launch vehicles and HTV, composed of "space transportation system technology," which is a key technology of national importance that is being promoted under the national long-term strategy in the Basic Plan. Also, as for GX launch vehicles, which is developed under the initiative of the private sector for the first time in Japan, the Ministry of Economy, Trade and Industry (METI) is in charge of R&D related to avionics that conducts the flight control of rockets, and JAXA is developing a liquefied natural gas (LNG) propulsion system that will become the second stage engine. Technical problems in the course of development of LNG propulsion system came to be solved in Fiscal 2006. Based on the evaluation implemented by the Space Activities Commission and other organizations in an appropriate time and way, development is implemented with an aim to deliver the technology of the engine to the private sector by Fiscal 2010.

In addition, the operation of the M-V launch vehicle, which is one of the highest-performance all-stage solid propellant rockets in the world, will finish with the launch of the 22nd scientific satellite "HINODE" (SOLAR-B) in September 2006 by M-V Launch Vehicle No.7. However, a new rocket is now being considered for the maintenance and development of solid propellant rockets.

(Telecommunication satellites system, positioning, navigation and timing satellite system, satellite observation and monitoring system, and satellite sensor technology and fundamental technology of satellite)

Utilization of satellites for communications, broadcasting, and other purposes offers a broad range of benefits in terms of wide-area use, broadcast simultaneity, durability following disasters, etc. To this end, the telecommunication satellites system, positioning, navigation and timing (PNT) satellite system, satellite observation and monitoring system, and satellite sensor technology and fundamental technology of satellites are selected as essential R&D issues.

Engineering Test Satellite VIII "KIKU No.8" (ETS-VIII), jointly developed by MEXT and the Ministry of Internal Affairs and Communications (MIC), to test and demonstrate large-scale satellite bus technologies for three-ton size satellites in stationary orbit, large deployable antenna technologies, mobile communication technologies of satellites and fundamental technologies related to satellite positioning systems utilizing high-accuracy clock standards, was launched in December 2006. Also, aimed for launch within Fiscal 2007, both Ministries are jointly developing the Wideband InterNetworking engineering test and Demonstration Satellite (WINDS). The objective of WINDS is to develop and demonstrate satellite communication technologies that enable ultrahigh-speed Internet/broadband data transmission and ultrahigh-speed networking technologies using satellite communication.

As for the PNT satellite system, under the cooperation

of MIC, MEXT, the Ministry of Economy, Trade and Industry (METI) and the Ministry of Land, Infrastructure and Transport (MLIT), research and development of a quasi-zenith satellite system that makes high-precision positioning, navigation and timing possible without being affected by mountain valleys or tall buildings are being implemented. Explanation of the satellite observation and monitoring system is included in 3 (1) and 7 (1) of Section 2, Chapter 2.

As for the research and development regarding satellite sensor technology and fundamental technology of satellites, the "Program to Improve Reliability (in relation to satellites)" is selected as strategically focused science and technology, and JAXA is working to improve the reliability of satellite bus technology and components.

(Manned space activities based on the International Space Station project)

Japan participates in the International Space Station (ISS) project as one of its essential R&D projects, aiming to accumulate technologies for manned space activities. This is an international cooperation project wherein Japan, the US, Europe, Canada and Russia jointly construct a space station in low earth orbit. Japan is participating in projects such as the development of the Japanese Experiment Module (JEM) "Kibo" and the development of HTV, which is selected as strategically focused science and technology.

Since the accident of the US space shuttle "Columbia" in February 2003, the assembly of ISS had been halted. However, the assembly restarted from the flight of space shuttle "Atlantis" in September 2006, and the project is progressing steadily towards the completion of ISS scheduled in 2010.

As for preparation for utilization of "Kibo" (JEM), JAXA is conducting microgravity experiments at a microgravity experiment facility (drop tower) and by aircraft (parabolic flights), and experiments of the High-quality Protein Crystallization, by using the ISS's Russian service module, as well as the Three-Dimensional Photonic Crystallization. To promote diversification for the ISS utilization, JAXA also provides space education events such as communication between high school students on the ground and ISS crew, and contests for the air-craft-based microgravity experiments conducted by university students.

(Solar system exploration and space astronomical observation)

JAXA serves as the center of space science in Japan by launching science-mission satellites and conducting research and development with the participation of researchers from various universities or academic institutes nationwide, and has made world-class achievements.

Japan is promoting the scientific satellite project as one of its essential R&D issues, and succeeded in launching the 22nd scientific satellite "HINODE" (SOLAR-B), which aims to elucidate the atmospherical structure of the Sun and causes of solar activities such as magnetic activities of the Sun, in September 2006. In addition, Japan is continuously promoting the development of The SELenological and ENgineering Explorer (SELENE), the 24th scientific satellite (Venus exploration project: PLANET-C) and Bepi Colombo (Mercury exploration project, an international cooperation project with the ESA).

(Promotion of international cooperation/collaboration)

Japan upholds the promotion of international cooperation/collaboration as a measure to promote frontier science. In accordance with global-scale problems that gradually become serious such as environmental changes and large-scale natural disasters, the necessity of earth observation satellite technology and the importance of multinational cooperation and collaboration in space technology are more serious than ever. Japan, through Asia-Pacific Regional Space Agency Forum (APRSAF), which serves as the host country, as well as other international conferences such as Committee on the Peaceful Uses of Outer Space (COPUOS) and Committee on Earth Observation Satellites (CEOS), aims for further promotion of international cooperation in the area of space science. Especially in Asia, Japan is promoting the development of "Disaster Management Support System in the Asia-Pacific Region (Sentinel-Asia) Project," wherein information of lands hit by disaster (including satellite images) is provided and shared via the Internet, under the cooperation of 19 countries, 44 institutes and 8 international organizations. The system started operation in Fiscal 2006.

(2) Ocean Development

(Promotion of research and development in frontier science (ocean))

Because observation and exploration of the oceans, which account for 70% of the surface of the Earth, contributes extensively in the society, from the clarification of global environment changes to disaster prevention/reduction and securing of resources, global efforts are being made in this area, mainly under the initiative of the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). In particular, for Japan, a maritime state surrounded on all four sides by ocean and possessing the world's sixth largest exclusive economic zone (EEZ), the research and development in the field of oceans is an important task that may change the future of the country. From such viewpoint, in the "Basic Concept and Promotional Measures for Ocean Development from the Long-range Outlook (Report from the Council for Science and Technology, August 2002)" it is stated that "for the development of ocean policies in the future, it is important to harmonize the three viewpoints, namely 'knowing the ocean (oceanic research/infrastructure development),' 'protecting the ocean (conservation of the ocean)' and 'using the ocean (usage of the ocean)' in a good balance, while showing strategic policies and promotional measures for the sustainable usage," and the Council is promoting ocean policies based on this idea. Also, concrete measures related to ocean development by each ministry are implemented based on the Ocean Development Promotional Plan summarized annually by the Liaison Committee of Ministries and Agencies Concerned with Ocean Development.

"Technology for the next generation ocean exploration system" and "offshore platform technology," both comprising the Key Technologies of National Importance "Earth Observation and Ocean Exploration System," were selected as strategically focused science and technology, under the Sectoral Promotion Strategy in frontier science (ocean) based on the Third Science and Technology Basic Plan. At the same time, the following three essential R&D issues were selected.

(Deep sea and deep seabed exploration technology, technology to utilize living marine resources)

MEXT is promoting the development of fundamental technology necessary for the observation/exploration of the oceans by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), and research on the oceans using such fundamental technology. For instance, "URASHIMA," an autonomous deep-sea exploration robot having the world record for the longest continuous autonomous cruise (317km), unraveled the surface structure of a mud volcano in deep seabed that may contribute to research on large-scale earthquakes in ocean trenches and methane hydrate resources. Also, "SHINKAI 6500," a manned research submersible with the world's top-level depth range (6,500m in depth), is used for research on creatures in the sea and extreme environmental conditions. In August 2006, it discovered life in extreme environmental conditions in sediment near the hydrothermal vent (chimney) located at the southern part of the Okinawa Trough, consuming methane, carbon dioxide and sulfur compounds as nutritional sources. In January 2007, it also discovered a blue hydrothermal emission ("Blue Smoker"), which is believed to be the world's first discovery, at the Hatoma Knoll hydrothermal field in the Okinawa Trough. As for strategically focused science and technology, "technology for next generation ocean exploration system" was selected as a technology comprising the Key Technologies of National Importance "Earth Observation and Ocean Exploration System," so MEXT is promoting the research and development for this technology through JAMSTEC. Among them, 1) development of deep sea riser drilling technology by deep sea drilling vessel "CHIKYU" started in Fiscal 2006. Riser drilling technology of "CHIKYU" is the world's first technology for scientific drilling, and in order to exert its potential at maximum, the project aims to develop the world's best deep sea riser drilling technology with drilling from 4,000m underwater. Utilizing this technology, the project will make a challenge to reach the mantle, a place where no human has ever been in the past, and to sample useful microorganisms. In addition, among the "technology for the next generation ocean exploration system," 2) the development of technology for a next-generation deep-sea cruising vessel, and 3) the development of technology for an unmanned research vehicle for deep ocean with high performance are scheduled to be started from Fiscal 2007.

The Ministry of Agriculture, Forestry and Fisheries has been focusing on the elucidation of ocean surface

ecologies to facilitate the rational utilization and management of marine living resources, and has also been working on the elucidation of the structure of deep sea ecologies and the relationship between mechanisms of change, and changes in ocean surface ecologies.

(Oceanic environment observation/forecasting technology, ocean usage technology, oceanic environment conservation technology)

MEXT is promoting observation prediction and simulation research on the global environment (observation of ocean, land and atmosphere and prediction/simulation of climate changes conducted around the world using observation facilities such as research vessels, buoys and terrestrial observation tools, aiming to clarify the global environmental changes including global warming) through JAMSTEC. For example, a new observation system for ice-covered sea was successfully installed near the North Pole in April 2006, realizing the world's first real-time observation/data transmission. Data obtained from this observation research are analyzed by using "Earth Simulator," a supercomputer with performance at the highest level in the world, and modeling research was conducted for physical, chemical and ecological programs of the global environment. In October 2006, it succeeded to predict the Indian Ocean Dipole (IOD), which is known as a cause of unusual weathers across the world, just like the El Nino phenomenon in the Pacific Ocean.

The National Institute of Information and Communications Technology, governed by the Ministry of Internal Affairs and Communication, conducts research into high-resolution three-dimensional microwave radar and shortwave ocean radar to facilitate the establishment of methods for the measurement of marine oil pollution, currents, and waves, etc., and the prediction of changes in the global environment, and implements joint observation in cooperation with universities and other research institutes.

The Ministry of Economy, Trade and Industry continues to implement surveys for reserves of oil and other resources in cooperation with Japan Oil, Gas and Metals National Corporation.

MLIT is working jointly with the Port and Airport Research Institute to improve the Nationwide Ocean Wave Information Network for Ports and Harbors (NOWPHAS).

The Japan Meteorological Agency is continuously implementing surveys and research to improve monitoring and observation information of ocean phenomena and climate changes, including the observation of oceanic and maritime climatic phenomena and the clarification of the El Nino phenomenon.

The National Maritime Research Institute is implementing research on safety and environmental conservation in terms of ocean technology. In relation to the North East Asian Regional-Global Ocean Observing System (NEAR-GOOS) project, the Japan Meteorological Agency and Japan Coast Guard operate a system for promoting the exchange of oceanic data for NEAR-GOOS area, furthering order to better promote oceanographic research.

The Geographical Survey Institute is implementing basic survey of coastal areas, for the purpose of providing the basic information necessary for the establishment of comprehensive development, utilization and conservation plans in the coastal areas.

The Japan Coast Guard is implementing research and development of surveying, observation and analysis technologies regarding ocean.

(Research on clarifying the inner structure of the Earth, undersea earthquakes and tsunami prevention technologies)

MEXT is promoting research on the dynamics of the Earth's interior, wherein surveys on crustal structure contributing in the dynamics analysis of ocean floor plates and survey on the delimitation of the continental shelf are implemented, using the remotely operated unmanned research vessel "KAIKO 7000" and deep sea research vessels. For example, development of an earthquake and tsunami observation system to monitor the magnitude of earthquakes and tsunamis or crustal movement in real-time at the predicted source zone of the Tonankai and Nankai Earthquakes, which may cause extensive damage in our country, started in Fiscal 2006. From September 2007, as the first international operation of the deep sea drilling vessel "CHIKYU," the launch of a drilling and research expedition is planned at Kumano-nada offshore of the Kii Peninsula. Through this expedition, it is expected that the generating mechanism of massive ocean-trench earthquakes will be unraveled. Furthermore, Liaison Committee of Ministries and Agencies Concerned with Continental Shelf Survey and Ocean Resources has been established, in order to promote the delimitation of the continental shelf of Japan. The entire government is

implementing surveys steadily, under cooperation among the Cabinet Secretariat, the Ministry of Foreign Affairs (MOFA), MLIT and METI.

Major research areas in frontier science implemented in Fiscal 2006 are as shown in Table 3-2-13.

Table 3-2-13 Major research areas in frontier science (FY2006)

Ministry or agency	Research institute or program	Subject
Ministry of Internal Affairs and Communications	National Institute of Information and Communications Technology	・Research into global environment measurement and forecasting technology using 3-D high-resolution imaging radar ・Research and development of ocean radar
Ministry of Education, Culture, Sports, Science and Technology	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	○ Technology for next generation ocean exploration system ・Development of the world's best deep sea riser drilling technology by "CHIKYU" ・Development of technology for next-generation deep-sea cruising vessel ・Development of technology for unmanned research vehicle for deep ocean with high performance
	Japan Aerospace Exploration Agency	○ Highly reliable space transportation system technology ・Development, manufacturing and launch of H-IIA launch vehicles ・H-IIB launch vehicles ・H-II transfer vehicles (HTV) ・GX launch vehicles ○ Technology to improve the reliability and functions of satellites ・Program to Improve Reliability (in Relation to Satellites)
Ministry of Agriculture, Forestry and Fisheries	Fisheries Research Agency	・Unraveling the cause of changes in marine living resources and the development of technology for high-precision forecast of changes
Ministry of Economy, Trade and Industry		・R&D in relation to the usage of slag ・R&D on remote sensing technology
	National Institute of Advanced Industrial Science and Technology (AIST)	・Prediction of Earth and ocean environments based on geochemical and palaeontological research of modern and past environments ・Marine geological research and survey
	New Energy and Industrial Technology Development Organization (NEDO)	・Project on the Development of Fundamental Technology for the Next-generation Transportation System Designing (GX launch vehicle)
	Japan Oil, Gas and Metals National Corporation (JOGMEC)	・Methane hydrate technology development ・Deep-sea mineral exploitation survey
Ministry of Land, Infrastructure and Transport	Maritime Bureau, Shipbuilding Division	・Development of natural gas hydrate (NGH) transportation vessel
	Hydrographic and Oceanographic Department, Japan Coast Guard	・IOC Sub-Commission for the Western Pacific Region (WESTPAC)
	Japan Meteorological Agency, Meteorological Research Institute	・Observational research on changes in ocean carbon cycle
	Geographical Survey Institute	・Basic survey of coastal areas
	Port and Airport Research Institute	・Research on the physical environment of coastal sand dunes ・Research on the clarification of the mechanism of ground liquefaction and deformation, and countermeasures/usage technology thereof ・Research on seawater flow and bottom sediment environment in coastal areas ・Research on works and monitoring by subsea robot

[Interdisciplinary areas]

3.2.2.9 Key Technologies of National Importance

In order for Japan to achieve sustainable growth and lead the world in the rapidly changing conditions, such as the restricted supplies of resources and energy, global warming and frequent occurrence of natural disasters, it is important to establish a long-term national strategy, and carefully select and promote important technologies.

To this end, the government selected five Key Technologies of National Importance, namely "Space transportation system technology," "Earth Observation and Ocean Exploration System," "FBR cycle technologies," "Next-generation supercomputer" and "X-ray free electron laser" upon the formulation of the Third Science and Technology Basic Plan.

These Key Technologies of National Importance are intended for the improvement of overall national security and the achievement of the world's top-level research function, and will be continuously promoted with high priority.

(1) Space transportation system technology

Refer to 3.2.2.8 (1).

(2) Earth Observation and Ocean Exploration System

In order to predict changes in the global environment, it is necessary to prepare a global observation network and to manage and data derived from the network. In addition, detailed topographic survey and resource exploration in sea areas surrounding Japan are necessary from the viewpoint of overall national security. The Earth Observation and Ocean Exploration System was selected as a Key Technology of National Importance in order to address these problems.

This Earth Observation and Ocean Exploration System aims to integrate, analyze and provide data obtained from observation and exploration from the oceans and space, and comprises three technologies, namely "technology for next generation ocean exploration system," "satellite observation monitoring system" and "data integration and analyzing system." The promotional framework for the entire system was evaluated in the Council for Science and Technology Policy in Fiscal 2006, and social contributions in the areas of global environment observation, disaster monitoring and resource exploration are expected in the future (Figure 3-2-14).

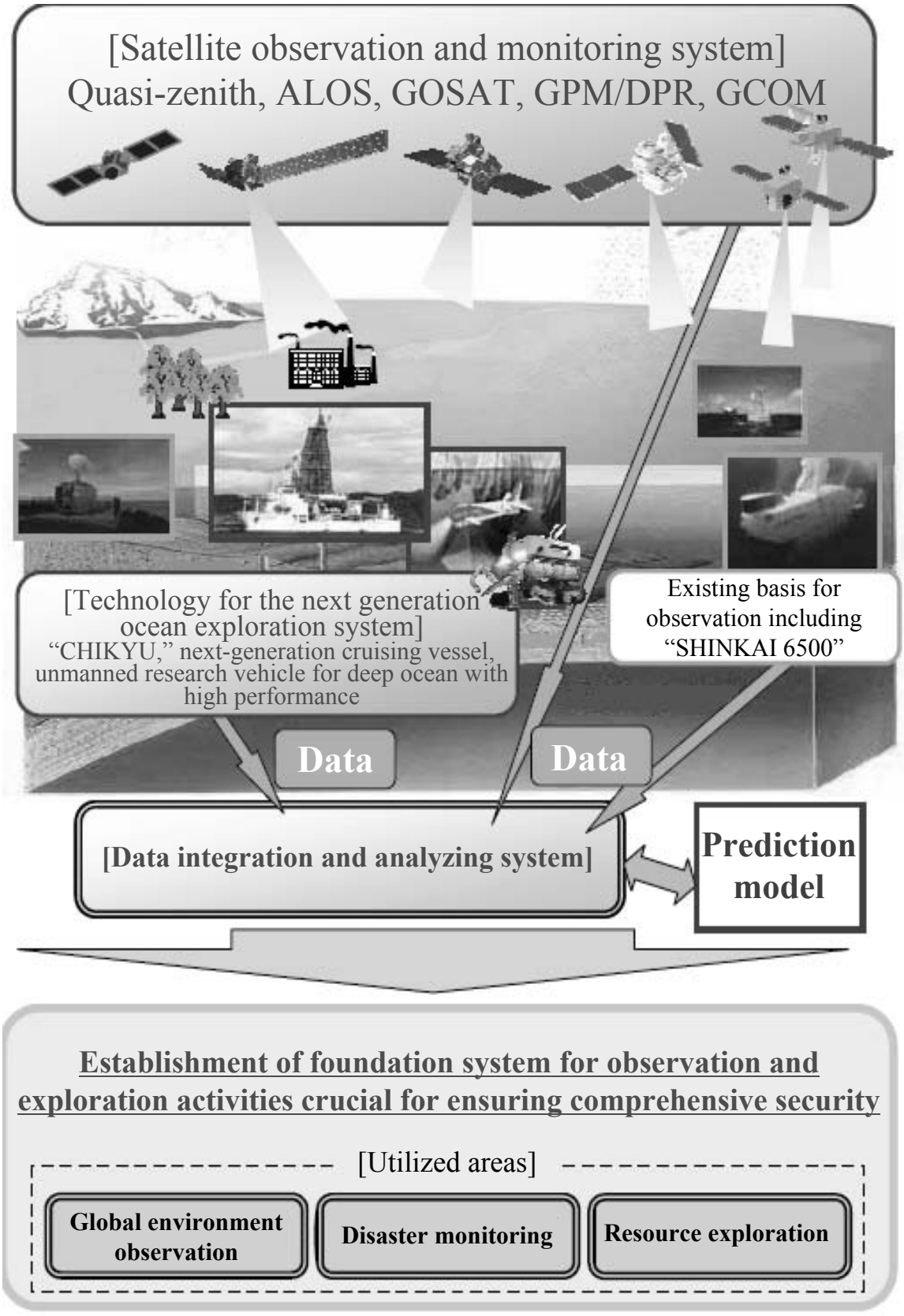


Figure 3-2-14 Conceptual Diagram of the Earth Observation and Ocean Exploration System

(3) FBR cycle technologies

Refer to 3.2.2.5 (1).

(4) Next-generation supercomputer

Simulation using supercomputers[20] is firmly establishing its position as the method of science and technology of modern days, together with theory and experiment. Because supercomputers enable a large-scale simulation at high speed, they are used for analysis of collisional damage of automobiles and forecast of the routes of typhoons or occurrence of concentrated heavy rain, etc. In order for Japan to maintain world-leading positions in a wide range of areas such as science and technology, academic research, industry, and medicine, MEXT started the project "Development and Use of State-of-the-art High-performance General-purpose Super computer" from Fiscal 2006. Aiming to start operation in Fiscal 2010 (and completion in 2012), the project is promoted by the Institute of Physical and Chemical Research (RIKEN) under close industry-academia-government collaboration.

The "Law for the Promotion of Public Utilization of the Specific Advanced Large Research Facilities" was enforced in July 2006, and MEXT mapped out the "Basic Policy for the Promotion of Public Utilization of the Specific High-speed Computer Facilities."

(5) X-ray free electron laser

X-ray free electron laser (XFEL) is a light having the combined features of laser and radiation light, and is a technology to allow analysis that is impossible with existing measures. Aiming for the realization of a research facility with the world's best performance, which allows instant measurement and analysis of the ultrafine structure of a single atom, ultrafast behavior and alteration from chemical reactions, the technology was selected as a Key Technology of National Importance and is currently being developed and improved. As a joint project with the Institute of Physical and Chemical Research (RIKEN) and Japan Synchrotron Radiation Research Institute (JASRI), the project is being developed as a facility attached to the synchrotron radiation facility SPring-8. It is expected to bring breakthroughs in a broad range of science and technology fields, including biological science and nanoregion structural analysis such as the analysis of membrane protein that is difficult to crystallize, real-time observation of catalytic reactions and the generation of new functional materials, as well as to contribute in the generation of new knowledge through innovative utilization research.

3.2.2.10 Science and Technology for a Safe and Secure Society

The Third Science and Technology Basic Plan gives "The world's safest country: Making Japan the world's safest country" as one of its goals, and promotes science and technology approaches conducive to the establishment of safe and secure society in accordance with the strategies for promotion of S&T priority fields.

The Project Team for Promotion of Science and Innovation for Safety and Security established under the Expert Panel on the Promotion Strategy for Prioritized Areas issued the "Safety and Security Science and Innovation Strategy" in June 2006. This Strategy includes the seven basic approaches that must be promoted during the period of the Basic Plan, including promotional measures for large-scale natural disasters, serious accidents, emerging and reemerging infectious disease, food safety, information security, terrorism and crime, and promotional measures such as the framework of research and development, international cooperation and human resource development against each of the aforementioned threats.

MEXT is promoting research and development on science and technology to cope with the above seven categories, and summarized the "Policy to Promote Research and Development on Science and Technology for a Safe and Secure Society" in July 2006. This Policy points out the necessity of a new research and development mechanism, to introduce the research results in public organizations and private businesses that is responsible for ensuring safety, and to promote research and development adequately responding to on-site needs.

Approaches for international cooperation are being promoted under the framework of bilateral science and technology cooperation agreements between Japan and the US, UK and France. In particular, the third workshop on the U.S.-Japan framework initiative for a safe and secure society was held in October 2006, and it was agreed that both countries will promote cooperation including joint research on science and technology for addressing terrorism and crime, and for protecting important infrastructure.

In addition, Research Institute of Science and

[20] Simulation: To conduct experiments virtually by using computers.

Technology for Society of Japan Science and Technology Agency promotes solution-providing research and development based on various on-site knowledge and experiences in the four areas of "Safety and Security," "Brain Science and Society," "Information and Society" and "Science/Technology and Human," utilizing knowledge not only in the area of natural sciences but also humanities and social sciences, for the objective of providing specific solutions for various problems in the society and contributing in social security.