Promotion Strategy for 8 Prioritized Areas

Life Sciences

Information and Communication Technology

Environmental Sciences

Nanotechnology and Materials

Energy

Manufacturing Technology

Infrastructure

Frontier (Outer Space and Oceans)

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Council for Science and Technology Policy

Life Science

1. Current Status of the Life Science Sector

(1) Current status

As symbolized in human genome research and the progress of developmental engineering, the 21st century is seen as the "century of life". The life science sector is expected to contribute to a diverse range of areas directly linked to human living, including the measure against various ailments, set to increase in this century, and the resolution to food / environmental problems.

The publication of draft sequence of human genome triggered post-genome research and an accelerated application of its results to associated industries. R&D competition is intensifying particularly in the area of medical application, such as pharmaceutical development and regenerative medicine, because of potential large profits. Amidst the situation, the United States (allocating 23.1 billion dollars to the NIH alone in the 2002 budget) and other industrialized nations have defined life science as the sector that leads economic development, and are intensifying their research efforts in the focal area.

Japan has long directed its resources in cancer research and brain science, and recently increased research funding to areas including the analysis of humangenome and protein structures. Yet, Japan lags behind the United States and Europe in genome science overall. Currently, Japan is making concentrated efforts in SNPs and the analysis of protein structures / functions etc., in a bid to turn the table in post-genome research and its industrial application. We are expected to further explore such research and accelerate the move to provide the benefit of research results back to the public.

(2) Current trends

Research in the life science sector, as seen in humangenome analysis, is turning into a "big science", with U.S. research showing outstanding strength qualitatively and quantitatively. At the same time, in the area of human genome and rice genome analyses, venture companies are using their mobility and abundant funds to conduct research at a pace outstripping international joint teams, causing concerns that they may monopolize the research results in the future.

Just as the development of the sequencer and PCR method has enabled the analysis of genome sequence, or as the establishment of ES cells created developmental biology, efforts to develop cutting-edge analysis technologies and breakthroughs in basic research are likely to directly lead to the creation of new industries and decisively affect the win / loss of research and industrial application.

(3) Tasks in technological innovation

Many research results in the life science sector are directly related to human dignity and health. It is therefore necessary to pay attention to ethical issues' the ripple effects and safety of new technologies in the course of practical application. For example, in applying results of advanced research, such as cutting-edge medical technologies or production of genetically modified organisms, to the areas of medicine or food production etc., we must examine their safety and help the public understand and accept their significance.

The progress of genome-related researches is highlighting the importance of integration with information / engineering technologies. Yet, Japan suffers from the shortage of human resources capable of supporting research and technologies in these fields. Fostering and securing the human resources is therefore the key task in strengthening national competitiveness in the post-genome age.

2. Areas of Focus

The life science sector is characterized by the fact that innovative discoveries and technologies in basic research may directly lead to the development of new research areas or industries. In view of this, it is necessary to actively promote world-class and creative R&D in emerging basic research and cross-category areas.

(1) Focuses

1) Developing disease prevention / treatment methods with genome-related technologies to achieve an active and vivid society of longevity

In the aging society with changing lifestyle, there is an alarming rate of increase in "lifestyle-related diseases" such as cancer, stroke, hypertension and diabetes, as well as senile conditions including dementia and immobility accompanied with aging. To extend national healthy life expectancy , research of the mechanism of such diseases and conditions must be conducted, and prevention/treatment technologies must be upgraded. As a nation in the most advanced stage of aging, Japan must initiate the research drive into this sector.

It is necessary to utilize research results and new technologies, undergoing rapid progress in recent years, in order to make a powerful promotion of R&D for extension of healthylife expectancy. As its foundation technologies, genetic polymorphism such as SNPs, proteome, protein structure / functions, brain function analysis, and bioinformatics must be strengthened. In the areas of disease treatment, new medical technologies such as regenerative medicine, gene therapy, immunotherapy, genome-based medicine development etc. must be applied, and simultaneously functional foods and new diagnosis technologies must be developed through examination of human health conditions / food functions, from perspectives for disease prevention. Researches should also be conducted to understand the body's integrated network system which controls complicated gene expression, metabolic reaction, signal transmission etc., and clarify the high-order functions of human life. To reach this end, R&D must focus on developing / expanding database, collecting / managing / supplying disease DNA samples, developing / collecting/ managing / supplying bioresources including mutant animals in laboratories.

2) Uncovering biophylactic mechanisms and disease prevention / treatment technologies for addressing environmental factors threatening public health

Efforts must be made to achieve a safe and secure living through resolving problems caused by infectious diseases, immunity / allergy ailments, carcinogens, hazardous substances in the environment (endocrine disruptors, etc.), serious amphixenosis etc. which threaten public health.

To this end, chemical substances and pathogens that cause such problems must be identified, to establish fundamental countermeasures. For infectious diseases, it is important to develop technologies for repressing disease manifestation, in addition to identifying infection mechanisms and developing treatments. The molecular-level studies based on genome research should be conducted on the biophylactic mechanism, so as to develop treatment methods with little side effects for infections, cancer, and immunity / allergy ailments by utilizing biophylactic mechanism. Treatment methods should also be advanced for serious epizootic diseases.

3) Promoting basic research on mental health and the brain, and applying the results to preventing / treating mental / neurotic illness

The recent upsurge in crimes and suicides related to daily anxiety and stress is shaping into a serious social problem. To resolve it, conventional psychiatric medicine must be promoted, while conducting research into human brain functions, human behavior and mental activities at the molecular level, utilizing leading-edge studies into brain / genome science, undergoing recent progress.

4)Developing advanced biotic technologies for producing useful substances and addressing environmental issues Japan is advanced in the area of producing useful organic substances through bioprocesses. In order to enhance our competitiveness, genome-related technologies (genome information, bioinformatics, etc.) must be utilized to make advanced application of diverse biological functions. In addition, recycling-oriented industrial systems, (e.g, reducing waste and environmental pollutants significantly) should be established through developing technologies for producing useful organic substances and breaking down environmental pollutants, thus enhancing industrial competitiveness.

Useful inherent characteristics of each organism must be utilized efficiently. R&D on this area should be accelerated through collecting unexplored biological resources and their genome information, including microorganisms which come from extreme environment and are difficult to culture, and developing the data into an intellectual foundation.

5) Developing food science / technologies for improving food supplies and diet

Innovative food production technologies for sustainable production must be developed to address food shortages associated with global environmental deterioration and population growth. Also technologies must be established to improve Japan's food supply capacity and secure / improve safe and affluent dietary living.

To achieve this, genome research into useful animals and plants must be conducted to analyze physiological function of these organisms . Cutting-edge technologies, such as genetic engineering and cloning should be used to develop innovative agricultural crops ,including the crops that can be grown with little strain on the environment.

In addition, Japan's food supply capacity should be enhanced through advancing technologies for managing crop / livestock production and lowering production costs, while establishing safe food production technologies.

6) Researching into emerging / integrated areas and developing cutting-edge technologies

New technologies and methods need to be developed to conduct creative research. To achieve this, it is essential to use nano-technology and information technology, which have progressed significantly in recent years with Japan contributing to a major extent. New areas such as bioinformatics, system biology, nano-biology, bio-imaging, should be explored and promoted , while efforts should be made to dramatically improve computer science, instrumentation technology and data processing capacity to support the move.

Application of such technologies is expected to lead to medical / diagnosis devices. Such devices as non-invasive diagnosis devices should be developed also from the perspective of developing prevention / treatment technologies.

7) Promoting research and developing systems for efficiently passing the benefits of cutting-edge research to society

In order to pass the benefits of research to society, it is essential to ensure the safety of medical technologies, genetically modified organism (GMO) and their use, and constantly win public acceptance of such technologies. In order to make industrial use of new GMO (in food, environmental remedy, industrial process) or make practical application of leading-edge medicine and pharmaceuticals, a system of scientifically and rationally ensuring the safety and effectiveness of new technologies must be developed, including developing a clinical trial system and associated guidelines.

From the perspective of bioethics, it is necessary to actively disclose information, provide education, conduct PR activities and enhance opinion exchange to win understanding from the majority of the public toward advanced research in the life science sector.

In addition, in order to return the benefits of medical research to society, clinical studies must be promoted and a system for facilitating swift application must be developed.

At the same time, research results should be used to form the foundation of industrial competitiveness through a support system for strategically ensuring IPR of research findings of university / other institutes and linking them to industrial use.

(2) Necessity / urgency for prioritization

1) Extending healthy life expectancy

As facing the trend of an aging society with a dwindling childbearing rate ahead of the rest of the world, Japan needs to extend the national long life expectancy to repress soaring medical costs for the elderly, reduce the burden of long-term care at home, and provide a high quality of living with health and vitality.

Japan has recently seen an increase in “lifestyle-related diseases” such as cancer, heart disease and stroke, and in senile conditions of immobility and dementia, etc. Japan should take the initiative in R&D for preventing / treating such conditions, thus extending the average period of independent and active life expectancy.

2) Ensuring a safe and secure living

Infectious diseases that threaten public life, and hazardous substances in the environment that affect human health, are emerging as major problems in society. Other social issues also include psychological problems in the developmental stage, and psychological / mental illness among adults and elderly, triggered by daily stress. It is necessary to resolve these issues attributable to various factors that threaten safe and secure living of the Japanese public.

In addition, safe, secure and affluent dietary living must be ensured through promoting food science / technologies and improving the nation’s food supply capacity.

3) Perspective of industrial competitiveness

Amidst protracted economic stagnation, there is a growing expectation toward science and technology fostering new industries. The life science sector encompasses applied categories, such as medical service, food, environmental conservation. We must maintain the perspective of correctly identifying the areas with a competitive edge, and prioritizing such areas with foresight.

Japan is internationally competitive in using bioprocess (using microorganisms, plants, etc.) to produce useful organic substances. Japan should also promote R&D using genome information of various animals, plants and microorganisms to address food / environmental tasks concerning the future global environment issues, and to accelerate industrial application of such technologies. It is important to advance the R&D, taking advantage of the nation’s characteristics.

3. R&D Targets in Focal Areas

(1) Developing prevention / treatment methods with genome-related technologies to achieve an active and vivid society with longevity

Identify the mechanism of "lifestyle-related diseases" such as cancer, stroke, hypertension and diabetes, or senile conditions of dementia and immobility, and develop technologies for preventing / treating them. This way, extend the national healthy life expectancy and bring about longevity society with vitality.

1) Genome analysis

Conduct typing analysis of tens of millions of SNPs per annum, in order to identify genes associated with lifestyle-related diseases (cancer, stroke, hypertension, diabetes) and senile conditions (dementia, immobility). Identify around 10 disease-related genes responsible for each ailment, and classify them according to the molecular etiology. Also, identify and analyze disease-related genes and genetic polymorphisms for selecting appropriate medicines and preventing side-effects.

2) Analysis of protein structures / functions

Develop technologies and systems for analyzing the structures / functions of over one-third of all basic protein configurations (approx. 3000 types) within 5 years, and enable to determine the structures of membrane protein and conjugated protein etc. whose structures are difficult to determine, so as to clarify the structures and functions of many useful proteins. Advance structural modeling and functional prediction technologies, so as to predict protein structures/functions based on DNA. Also, reveal the structures / functions of modificatory proteins, such as with addition of sugar-chains, to facilitate the development of new types of medicines.

3) Analysis at the cell / tissue / individual levels

Conduct research / technological development for an integrated understanding of biological responses as systems. Apply the results to uncovering the cause of, diagnosing and treating diseases, and establish the method of predicting pharmaceutical effects / side effects and developing pharmaceuticals rapidly and efficiently.

4) Bioinformatics

Use IT to integrate / systemize a large amount of diverse data, discover new knowledge and conduct simulation, so as to achieve at enhanced efficiency in analytical studies described above, and develop theories / methodologies for understanding life as a type of system.

5) Medicine development (especially genome-analysis based medicine)

Use the results of genome analysis and protein structural / functional analysis, to halve the time required to develop medicine up to the clinical testing stage.

6) Tailor-made medical services

Develop technologies for facilitating fast, accurate and affordable analysis of genetic polymorphism and gene expression at the clinically applicable level. Achieve efficient prescription of medicines suitable to individual predisposition.

7) Regenerative medicine / gene therapy

Develop technologies for manipulating cell differentiation and multiplication of different kinds of stem cells, so as to achieve safe cell therapy for various diseases with symptoms accompanied by tissue / cell loss. Also, develop the foundation technology for gene therapy.

8) Functional foods

Identify functional components that provide functions of preventing lifestyle-related diseases or deterioration of anti-oxidant and brain functions etc., and develop food products incorporating such functions.

9) Prevention / diagnosis / treatment technologies

Develop prevention technologies applying the analysis of genetic polymorphism and gene expression etc., in order to lower the case rate of lifestyle-related diseases. Also, develop non-invasive or low-invasive diagnosis devices and treatment methods.

(2) Uncovering the biophylactic mechanismsand disease prevention / treatment technologies for addressing environmental factors threatening public health

Work toward resolving various problems caused by infections, immunity / allergy ailments, carcinogens, endocrine disruptors, and other hazardous materials in the environment that threaten safe and secure public living. To this end, identify behavior of such chemical / pathogenic matters in the environment, infection route , and manifestation of pathogenic properties, as well as biophylactic mechanisms against such elements, so as to develop new prevention/treatment technologies against infection.

1) Identifying biophylactic mechanisms

Identify biophylactic mechanisms on the molecular level to establish a comprehensive understanding.

2) Finding the cause of hazardous substances in the environment

Identify how hazardous substances etc., currently under scrutiny, affect human body, and develop a fundamental way of resolving diseases triggered by them.

3) Identifying the mechanism of pathogenic property manifestation

Identify the mechanism of how infectious diseases (Hepatitis C, O-157, BSE, influenza, etc.) manifest themselves, so as to develop technologies for preventing infections of or repressing manifestation of such diseases through development vaccine , etc. In addition, resolve infectious diseases, which might come to the surface in the future, by identifying their pathogens.

4) Developing new prevention / treatment technologies

Use the biophylactic mechanism of organisms to develop ways of preventing / treating infections, cancer, and immunity / allergy ailments. Also, establish ways of diagnosing serious epizootic diseases and technologies for preventing / treating antibiotic-resistant bacteria through innovative way of thinking.

(3) Promoting basic research into mental health and the brain, and applying the results to preventing / treating mental / neurotic illnesses

Promote brain science research to maintain the mental / brain health through overcoming psychological problems that develop in the brain's developmental stage, psychological disorders caused by daily / workplace stress, and various brain disorders among the adult population, which have been recognized as recent social problem. At the same time, promote a multi-faceted approach of integrating basic / clinical medicine with psychology, behavioral science, information science, epidemiology, genome science, etc. Also, identifying the cause of diseases, and develop innovative ways of preventing, diagnosing and treating diseases, and enhance research infrastructures.

1) Basic / integrated research into brain functions and its application
Take an integrated approach in brain studies from the single-cell level to the overall function as a human organ, to identify molecules with nervous functions, develop technologies for brain image analysis, and uncover the brain's high-order functions as an integral system. Using the biology on brain development and growth as the basis, discover the developmental principles of human cognition, behavior and thought.

2) Integration of brain science with behavioral science, psychology, information science, etc.
Integrate brain science with behavioral science, psychology, information science, etc., to grasp how various stimulations affect human mind and brain. Also, establish a broader contact of brain science with human / social science (e.g. pedagogics).

3) Developing innovative prevention / diagnosis / treatment technologies
Identify the manifestation mechanism of neural conditions (Alzheimer's Disease, Parkinson's Disease, etc.), mental illness, and various developmental disorders of the brain etc., and develop innovative ways of diagnosing / treating such conditions including genetic markers. Promote research into the clinical application of non-invasive measurement methods for brain functions.

(4) Developing advanced biotic technologies for producing useful substances and addressing environmental issues

Utilize genome information, which is rapidly accumulating recently, and genome-related technologies, now making notable progress, to make advanced use of various biotic functions to efficiently produce useful organic substances or to develop industrial technologies for addressing environmental issues (e.g. disintegrating environmental pollutants), and intensify nation's competitiveness. To this end, gather useful genetic resources and genome information, and compile them as an intellectual foundation.

1) Analysis at the gene/protein level
Accumulate genetic information from a diverse range of organisms and data on protein structure / function, and utilize bioinformatics to detect useful genes and enable high-precision molecular design of intended proteins.

2) Analysis at the cell / tissue / individual levels
Use model organisms with identified genome information to achieve an integrated understanding of biological responses based on metabolism simulation etc., so as to establish technologies for reconfiguring cell functions. Also, develop the imaging technologies for cell functions for advanced analysis.

3) Developing technologies for advanced use of biological functions

Develop technologies for advanced use of biological functions (e.g., genetic engineering, cloning), and achieve practical application of various industrial technologies such as effective production and functional modification of useful organic substances, and disintegration of environmental pollutants.

4) Biological genetic resources

Develop a system for collecting, conserving, managing and supplying genetic resources of a diverse range of microorganisms, animals, plants, etc. including microorganisms in the extreme environment. Also develop a technology and a system for utilizing DNA of microorganisms which are difficult to culture, etc.

(5) Developing food science / technology for improving food supplies and diet

Develop innovative technologies for sustainable food production, so as to address future food shortages as a result of a deteriorating global environment and rapid population growth around the world. Also, develop technologies for producing high-quality, safe and healthy foods to enhance the nation's food supply capacity.

1) Analyzing plants' physiological functions and developing genetically engineered plants

Research genome information and gene functions of model plants and agricultural plants. Based on the information, identify how to control the plant's form and functions, along with contributing genetic factors. Find attributable genes and their manifestation mechanisms for environmental stress resistance (dryness-resistance, low temperature resistance, salt resistance, etc.), productivity and pest / disease resistance. Develop innovative crops with environmental stress resistance and high productivity.

2) Developing high-quality crops / foods for maintaining and improving health

Use cutting-edge technologies (genetic marker, cloning, etc.) to create safe crops / foods for maintaining and improving health, and develop technologies for maintaining their quality.

3) Advancing technologies for animal / plant production / management and ensuring safety

Develop systems and devices for safely, efficiently and sustainably producing and managing crops and livestock. Also, enhance the technologies for food sanitation control, such as evaluating microorganisms / hazardous substances.

(6) Researching into emerging / integrated areas and developing cutting-edge technologies

Promote the areas integrating life science with information technology and nano-technology , which have developed significantly in recent years, with Japan making major contribution. Also, seek practical application of new advanced analysis technologies.

1) Forming emerging / integration areas

Pioneer new areas, such as bioinformatics, nano-biology and system biology through integrating with engineering, physiology, medicine and agriculture, e.g., so as to develop technologies for analyzing / collecting and processing various levels of biological information efficiently, including human resources of the area. Seek the creation of new life science areas through these efforts.

2) Developing cutting-edge analysis technologies

Develop next-generation analysis technologies, such as bio-imaging technologies (non-invasive imaging devices for intercellular molecular reaction, etc.), unicellular function analysis technologies and unimolecular function analysis technologies. Also, efficiently make industrial application of such technologies.

(7) Promoting research and developing systems for efficiently passing the benefits of cutting-edge research to society

Examine the safety and their use of advanced medical technologies and genetically modified organism (GMO), and promote public acceptance on bio-ethics issues, in order to pass the benefits of life science research to society. Also, develop a support system for strategically protecting intellectual property rights (IPR) of research results, so that the results can be used as the foundation for building industrial competitiveness.

1) Promoting clinical application of cutting-edge researchers

Establish several bases in Japan to efficiently conduct translational research into applying basic research results to clinical studies and promote these researches. At the same time, develop a system of scientifically screening effectiveness and safety.

2) Research for facilitating clinical trials and evidence-based medicine (EBM)

Promote clinical research under corporate initiatives in order to prevent the hollowing-out of medical technology development in Japan. Also, promote clinical research for obtaining scientific evidence on the effectiveness of prevention / treatment methods under the initiative of researchers and doctors. To facilitate these efforts, develop and expand support systems including statisticians, clinical epidemologists, clinical research coordinators, etc., thus shortening the time required for clinical trials.

3) Safety of GMO

Scientifically examine and evaluate the safety of GMO. Accumulate such data and promote PR and other campaigns to raise social acceptance of the technology.

4) Bio-ethics

Conduct studies into various ethical and social problems, accompanying the rapid progress of life science, such as genetic testing, regenerative medicine and reproductive medicine. At the same time, implement various measures to broadly form public consensus.

5) Support system for turning research results into intellectual property

Enhance the system for identifying useful discoveries from university research results, etc., and protecting them as intellectual property. To this end, strengthen efforts to increase the number of patent attorneys specializing in life science, train such human resources, and secure people capable of identifying discoveries of high potential, because these human resources are lacking in the life science sector.

4. Basic Issues for Promoting R&D

(1) Enhancing the national approach

Research investments into the life science sector are expanding globally. The areas of research and application are also extending diversely, while concerning ministries in Japanese are said to be implementing their projects with their own perspective. Since a smaller scale of research fund is available compared to the United States, researches in Japan must be effectively promoted in the organic coordination among ministries under a clearly defined strategy. For example, a system, which comprehensively evaluates and assists each ministry's projects, should promote projects of large-scale or required coordinated approach, such as analysis of protein structures / functions, translational research, and development of genetic biological resources, as well as the millennium genome project.
In implementing these measures, it is necessary to broadly use competitive funds to attract high-quality human resources.

(2) Effective business-academia-government collaboration
In life science, the results of basic research often lead directly to practical application. Precious research results can be linked to businesses without waste, if universities and national research institutes that conduct basic research coordinate , from the early stage, with companies that carry out application studies.
For example, in the study of protein structures / functions intended for developing new medicine, it is important for researchers to forge partnership with companies to effectively select useful proteins and utilize the findings on protein structures / functions. Bases and systems for efficiently promoting the study of protein structures/functions should be established, so as to administrate projects in a way that enables amassing full capacity of Japan in experimental samples, research facilities, human resources, etc. To achieve it, every ministry's projects should be overseen totally to develop a system of effectively promoting the study of protein structures / functions overall.
The flow of human resources should also be encouraged between the business, academic and governmental sectors through measures, such as supporting venture businesses.
In addition, organic coordination should be established between prefectural governments, businesses, universities and public research institutes from the viewpoint of promoting regional development of science and technology.

(3) Developing the system for passing research results to society
As described in 3. (7), in order to pass the results of life science research to society, systems/regulations must be facilitated and also national acceptance to cutting-edge technologies in life sciences should be cultivated through plain explanation of scientific examination of safety and effectiveness. The issue of bio-ethics, especially, has become a major problem, with the remarkable progress in genome analysis, cloning technology, etc. Bio-ethics must be examined further academically and multi-directionally. In order to win public understanding, it is extremely important to make active information disclosure in proceeding with research and contributing to industrial development and improvement of standard of living.

(4) Establishing and expanding common foundation including genetic biological resources
To promote research in the life science sector, it is necessary to develop a database for accumulating and sorting enormous information on genes / proteins, to improve data-processing capacity, and to advance computer science.
The government should take charge of collecting, conserving, maintaining, managing and supplying diverse genetic biological resources (disease-model mice, microorganisms, animals and plants, etc.), as

this requires long-term, continuous operations.

Research infrastructures should be developed to promote basic research and industrial application, because it is important to secure experimental materials, including samples for research into brain science and mental / neuro science, disease-related gene samples for their analysis, and human cells / tissues for pharmaceutical development, etc.

(5) Human resource development in integrated areas

As symbolized in human resource shortages in bioinformatics and development of cutting-edge analysis / treatment devices, Japan lags behind the United States in human resources in areas integrating with engineering, physical science, medicine, agriculture, etc. It is necessary to train and secure human resources for these areas that will support new development in life sciences. To this end, universities and other research institutions should develop education / research bases and organizations flexibly, to pioneer new category areas as described above, and develop required human resources. And also it is required to revitalize science education at high schools, and to prepare an environment where many researchers from overseas can gather in Japan and exert their talents.

Information and Communication

1. Current Status of the Information / Communication Sector

(1) Current trends and surrounding environment

"Information and Communications Technology (IT) is one of the most potent forces in shaping the twenty-first century"— Okinawa Charter on Global Information Society

The field of information and communication has progressed from the days of bulky telephones and large computers to the Internet, personal computers, and mobile phones at speeds that far exceed people's expectations. Consequently, the IT industry has grown to lead Japan's economic development (with an economic size of approx. 49 trillion yen, [value added] accounting for 9.4% of all industry totals and for 7.4% of all employment). The Japanese economy has become increasingly dependent on the IT industry, even in comparison with the United States (where IT accounts for 8% of the economy and 5% of the employment). Therefore, a decline in international competitiveness in this sector would deal a significant blow to the nation's economy. The information / communication sector is expected to create 860,000 jobs by 2004, expand the e-commerce market to approx. 123 trillion yen by 2005, and dramatically revolutionize people's lifestyles, society as a whole, and the economy (including businesses, public services, science / technology, etc.). Although the hype surrounding the IT industry has decreased, high expectations remain that IT will significantly improve productivity and communication between consumers and suppliers, increase new business opportunities, and bring about higher international competitiveness. This sector is believed to serve as a new source of power for further developing the world economy.

Meanwhile, Japan lags behind Europe, the United States and some Asian nations in the use of broadband Internet connectivity, e-commerce, e-government and cyber security technology. The IT Strategic Headquarters is currently promoting measures to improve this situation, based on the e-Japan Strategy, aimed at making Japan the world's most advanced IT nation within 5 years. By 2005, Japan will see the completion of a safe and reliable advanced IT network, which will rapidly accelerate Internet use, online corporate activities (e-commerce, etc.), and electronic handling of administrative services. This will further heighten our socio-economic dependence on IT.

Information / communication technology and its uses are changing at a faster pace. Just as the world promptly switched from fixed to mobile phones in the present, so too will many people and organizations use diverse IT equipment and networks that reach all corners of the world. This will allow us to be liberated from geographical constraints and to exchange information on a global scale, thus achieving a higher level of creativity and a society with efficient socio-economic activities. (Figure 1)

(2) Technological innovation tasks

Despite the significant positioning of the information / communication sector, Japan's technological competitiveness in this area is on the decline overall, compared with that of the United States and Europe. There is a rapidly widening gap in private-sector R&D investments between Japan and the United States. Because Japanese businesses are shifting their focus on product development, the government must play an increased role in the R&D of high-risk areas so as to enhance the nation's competitiveness. Japan is also behind the United States in its capacity to apply R&D findings to actual business, failing to fully use the results of basic research.

Also, Japan's R&D puts too much emphasis on technological components and is said to continue to lag in its ability for system vision / development. Yet, the nation leads others in creating new service formats in mobile- phone-based Internet and creating new markets around the world. If we use our technological characteristics appropriately and strengthen our collaboration among industry, university, and public research organizations , Japan is fully capable of developing cutting-edge systems, contributing to creating a new IT usage / world market, and ensuring competitiveness in applicable fields.

The United States and Europe are conducting comprehensive R&D programs, while Asian countries are fostering many advanced IT technicians. In contrast, Japan has yet to draw up a comprehensive R&D program for the IT sector and suffers drastic shortages in researchers / technicians for software development, Internet, etc. Researchers for studying IT infrastructures are also in short supply.

(3) Current measures

Thus far, the government has distributed R&D projects to the Ministry of Public Management, Home Affairs, Posts, and Telecommunications (advanced network development, human interface, etc.), the Ministry of Economy, Trade, and Industry (high-performance computing, devices, software, etc.) and the Ministry of Education, Culture, Sports, Science, and Technology (R&D infrastructures, space development [communications], basic research, etc.). Yet, some competition may be desirable in areas of basic and innovative research, including bioinformatics. However, the aforementioned ministries are not necessarily making conscious efforts to coordinate policy to improve competition. To improve R&D efficiency, relevant government offices must promote competition more consciously, while maintaining a mutual liaison. Efforts are also being made to develop a collaboration among industry, university, and public research organizations, but a lack of clusters for gathering and integrating contributions from those sectors, especially from universities, has been a problem.

2. Areas of Focus

(1) Priority approach

While emphasizing quality in basic research for an international standard, Japan must prioritize R&D as described below to achieve the goals set out in the "Science and Technology Basic Plan", i.e., "scientific knowledge creation and use", "international competitiveness and sustainable development", and "safe, secure, and comfortable living."

Because Japan is highly dependent on the information / communication sector, the effort to promote R&D and apply its findings to practical use must be increased, so as to strengthen "international competitiveness of Japan." With the corporate use of information / communication recognized as one of the most powerful forces for growth, a country that makes a practical application for the latest IT technologies and enables it to proliferate ahead of other nations will benefit sooner. To become the "world's most advanced IT nation", Japan must lead the rest of the world in applying the findings of the latest R&D and in incorporating it into society and the economy. To this end, priority should be given to R&D in areas that can be swiftly reflected in socio-economic activities. It should also be noted that, unless information / communication systems are "safe, secure, and comfortable" for use by all persons and organizations, the systems will not proliferate and may cause serious problems.

In addition to these short-term perspectives, we need to proceed with basic R&D to make technological breakthroughs so as to enhance our "international competitiveness" and promote "scientific knowledge creation and use" in the long term. The information / communication sector, by its very nature, expands into various R&D areas and provides the foundation for more comprehensive R&D. Developing and improving IT systems for facilitating cross-category / comprehensive R&D activities is therefore important.

In view of these tasks, R&D must be promoted in 1) areas for swift social / industrial application so as to achieve a ubiquitous network society, in 2) areas combining other industrial sectors with next-generation communication / IT technologies that will bring about technological breakthroughs and new industries, and in 3) areas of basic technologies for introducing IT as the foundation for comprehensive R&D activities.

1) R&D areas for achieving a ubiquitous network society

To revamp Japan's dwindling international competitiveness in the information / communication sector, to revitalize its economy, and to create safer, more secure, and more comfortable lifestyles, Japan must conduct R&D in collaboration among industry, university, and public research organizations and under a flexible environment with low restrictions. Japan should give priority to areas in which it excels, with a view to providing IT systems the market requires in achieving a ubiquitous network society. Developing a high-speed and highly reliable IT system ahead of the rest of the world will lead to the creation of new markets and subsequently help establish Japan's leadership in terms of technological / industrial competitiveness. Such R&D activities, however, must not create products solely for the Japanese market, but rather ones that will be broadly accepted in world markets. The goal of establishing international standards should also be set.

For now, the key to ensuring Japan's international competitiveness lies in infrastructure technologies, e.g., high-speed network technologies and support devices for creating an ultra-fast mobile

Internet system. Also, to create safer, more secure, and more comfortable lifestyles, a sufficient level of security and reliability must be established. This is because the socio-economic infrastructures handling important data concern people's lives, assets, privacy, etc. Improving service convenience and diversity of contents (production / distribution), including those for the elderly and the handicapped (to whom there is little incentive for private sector operators), is also important as a way of resolving the "digital divide" issue.

2) R&D areas for achieving next-generation breakthroughs to create new industries

The findings of basic R&D have begun to create new industries; also the findings in the information / communication sector have provided technological innovation. R&D should therefore be promoted in basic yet "blooming" areas for creating next-generation breakthroughs as an investment in the future.

Information / communication technologies are used in broad socio-economic activities, the scope of which is continuing to expand. Even in the areas of science and technology, areas / categories where IT is serving a significant role are expanding rapidly. Such cross-category R&D should also be promoted.

3) Foundation technologies for broader areas of R&D (IT introduction for R&D)

IT is an important infrastructure for science and technology and is expected to significantly impact on the way researchers exchange information with each other and conduct research. Implementing the R&D of shared technological components for computer science and introducing IT to R&D activities further is therefore important. Because IT requires having personnel with diverse ideas, enhancing human resource development is a task of particular importance.

(2) Focuses

The following areas will be given priority focus.

1) "High-speed, highly reliable IT system" technology

Toward the goal of achieving a ubiquitous network society, efforts should be made to enhance industrial competitiveness and improve the standard of living. To this end, industry, university, and public research organizations must cooperatively explore the technological areas in which Japan excels (mobile communications, fiber optics, device technology, etc.). They must develop a "high-speed, highly reliable IT system" combining hardware and software technologies (including content) ahead of the rest of the world, as a way of swiftly applying research findings to society and the economy.

The following R&D should be promoted.

(i) Technology for achieving an ultra-high-speed mobile Internet system

Technology capable of exchanging / using a large amount of high quality data via wireless or fiber optic networks anytime and anywhere (e.g., at home, at the office, or during traveling) and of facilitating advanced Internet services

(ii) Technology for devices that have many features but consume little power

Technology for developing these devices, required for achieving high-performance mobile data terminals and high-speed networks (including semiconductor processes, system LSI, and flat display technologies)

(Note) Semiconductor / device technologies have been one of the areas from which Japan has drawn its IT industry competitiveness. Based on this, promote R&D in making cutting-edge semiconductor process technology, devices VLSI that have many features but consume little power.

(iii) Technology for advanced computing

Work toward improving convenience*, security, reliability**, system expandability / continuity, software reliability / productivity, and content production / distribution must be supported***. Also, technologies for using computing power, software, contents, and other IT resources spread across different conditions (location, time, etc.) via networks with flexibility and security must be developed.

* Advanced database technology for swiftly searching necessary data from a network, high-volume storage technology for storing large volumes of data, technology for resolving the issue of the digital divide, etc.

** Technology for improving security / reliability (including evaluation), such as those eliminating unauthorized access, maintaining information confidentiality, and restoring the system swiftly upon errors.

*** As for R&D areas that have been concurrently difficult to have clear targets for achievement defined, researchers should be given the freedom of exploring them, while, as much as possible, indicating the future outlook. This type of R&D needs to be actively explored and expanded.

In the next five years, we should aim at establishing world leadership in (i) and (ii) and achieving the world's cutting-edge standards in (iii).

Note that, in this category, what counts is whether you can develop the desired systems in the end. Industry, university, and public research organizations must fully discuss them and make a flexible and optimum distribution of responsibilities so that each of them can exercise their capacity most effectively and to maximum effect.

2) Next-generation information / communication technologies

R&D must be promoted for next-generation information / communication technologies that use new principles and technologies including next-generation human interface and quantum engineering. In this category, the government should take the initiative in drawing out the capacities of the industry and university organizations, while also respecting voluntary R&D efforts in the private sector.

Conducting R&D in advanced information / communication technologies is also important in collaboration with other industry sectors, such as advanced traffic information systems (ITS, etc.), space development for communications, environment, nanotechnology, bioinformatics, disaster control, and robotics. In this category, industry, university, and public research organizations should flexibly share responsibilities according to R&D themes.

3) Foundation technology for broader R&D areas (IT introduction for R&D)

Within five years, technological development / improvement will be made to compile a science and technology database, where Japan lags behind the United States and Europe. Also, supercomputer networks, virtual laboratories, etc., will need to be developed to provide high-speed links between research institutes and universities for enabling joint research between remote establishments. R&D will also be promoted for computing science technologies to simulate biological / technical themes, e.g., molecular / atomic movements and structures, meteorological phenomena and the environment. Developing faster supercomputers will be pursued according to the demands from various areas of research.

4) Human resource development / maintenance

The information / communication sector, particularly software, Internet, and other areas, in conjunction with different industry sectors, suffers from serious shortages in researchers and highly skilled experts. A system must be developed urgently to foster and ensure human resources at an international level.

3. R&D Targets in Focal Areas

The following lists each focal area's main R&D targets in the next five years.

(1) R&D area for achieving a ubiquitous network society (5-year target)

+ Technologies for ultra-high-speed mobile Internet systems
  - Wireless access:
    At hundreds-of-Mbps level (practical application level when moving at low speed)
    At scores-of-Mbps (practical application level when moving at high speed)
    100-Mbps levels (demonstration level),
    Using of software wireless technology to support multiple frequency bands and methods
  - Optical communication*:
    Per cable at 10-Tbps (practical application level) and 1-Pbps levels (basic technology)
    Optical router at 10-Tbps (practical application level) and hundreds-of-Tbps levels (basic technology)
    *Assuming 1-Gbps level (offices) and 30 to 100-Mbps level (home use) in wired access systems
  - Next-generation Internet:
    IPv6 delivering large-scale connectivity (nodes) and excellent real-time transmission (practical application level)

+ Technologies for devices that have many features but consume little power
  - Compact and lightweight (SoC): Single chip for TV encoding, voice recognition, and synthesizing
  - High-speed (SoC*): 1-GHz (practical application level) and 3-GHz levels (experiment level)
  - Low power consumption*: Multi-feature mobile terminal that works for one week without charging
  *When a Nitride Film gate / balanced CMOS is present

+ Technologies for improving convenience, security, and reliability
  - Voice recognition:
    Real-time recognition of tens of thousands of words / phrases in a noise-mixed environment (practical application level)
    Real-time recognition of millions of words / phrases, differentiating multiple speakers (experiment level)
  - Database:
    Database capable of handling simultaneous access from 100,000 people or more
  - Security:
    Controlling unauthorized access, providing advanced encryption / authentication, making aggressive tracing, etc. (practical application level)
  - High reliability:
    Error time of less than an hour per annum, and automatic recovery (large servers)
    Network reliability management (practical application level for small systems,

experimental level for large systems)

Achieving basic technologies for enhancing system reliability / security to prevent data loss, etc.

- Software / digital contents:

Establishing ways to enhance software reliability / productivity, achieving a digital right management system (practical application level)

(2) R&D area for achieving next-generation breakthroughs

1) Next-generation information / communication technologies (basic technologies for supporting breakthroughs in 10 years or more)

+ Next-generation human interface technologies, including semantic understanding technology

Achieving a level at which user intention is deduced from circumstances

+ IT using quantum engineering

Quantum encryption key distribution in a relatively short distance (up to scores of kilometers), a quantum communication prototype, etc.

2) Cross-category areas (5 years)

+ Advanced traffic information system (ITS, etc.): Safe driving support system (danger alert, driving support), advanced ITS using a next-generation Internet service

+ Space development (communications): High-speed Internet communications at the Gigabit level, etc.

+ Bioinformatics: 3D-structural projection of small / medium proteins, precise gene identification, intercellular metabolism simulation technology

(3) Foundation technologies for broader R&D (5 years)

+ Science and technology database: Digitizing data, developing search systems

+ Supercomputer network: Linking laboratory / university supercomputers with high-speed networks to facilitate joint research between remote institutions

4. Measures and basic issues for promoting R&D

(1) Role sharing and tri-organizational collaboration

In promoting the R&D of focal areas, the government should provide a flexible system to accommodate changes in R&D programs, particularly in a sector characterized with diversity and fast-paced innovation. At the same time, focus should be placed on fundamental yet pioneering areas that cannot be achieved strategically and effectively if left up to the market principle. To provide R&D benefits quickly to society and industries, we must be highly aware of practicality in selecting themes and must develop a system for strongly promoting the coordination among industry, university, and public research organizations between. This coordination must be done to work out tax incentives, etc., for universities' research revenues, corporate donation income, and other sources of support. Support systems for joint research, etc., should also be established, while efforts must be made to prepare an environment whereby researchers receive sufficient incentives to put research findings into business application. The following system should be then taken under the collaboration of the three organizations to promote R&D for bridging the findings of Japan's unique basic research to practical application.

In the process, we must ensure the maximum effect for government-funded R&D through eliminating redundant research projects that have similar themes, goals, and methods (due to an absence of competition) and through providing a competition-oriented R&D environment. In such an environment, research scientists using different methodology, including basic research, can compete against each other. Also, when carrying out R&D projects under the tri-organizational collaboration, full considerations should be given to reducing the administrative burden of business and academic parties. An R&D system should be developed to coordinate and concentrate effectively the measures of various government offices so as to achieve the intended goals.

1) "High-speed, highly reliable information / communication system"

The industry, university, and public research organizations should work closely, while fully using the R&D capacity of the private sector, who will be the ultimate beneficiary of such projects. R&D themes that can be put to practical use in around 5 years should be actively pursued with the government bridging research under a collaboration among industry, university, and public research organizations, while respecting voluntary R&D in the private sector.

2) Next-generation information / communication technologies

The government should take the initiative in fully exploring the R&D capacity of the business and academic communities, while respecting voluntary R&D in the private sector. In doing so, an adequate environment for competition should be provided in areas that include basic research.

3) Cross-category areas

The government should take the central role in conducting large-scale projects such as advanced traffic information systems (using ITS, etc.) and space development for communications. A government initiative should also be exercised for emerging areas such as bioinformatics, while the R&D trends of the private sector are observed. Regarding nanotechnologies, those eyed for business / industrial application in 5 to 10 years should be subject to concentrated R&D under a tri-organization collaboration, whereas those for application in 10 to 20 years should be explored using competitive funds.

4) R&D infrastructures

The government should enhance national / university R&D infrastructures by developing necessary technologies in around 5 years. Supercomputer networks should be developed, administrated, and evaluated, initially linking institutions that have specific joint research themes. Rapidly integrating networks linking national laboratories and universities for shared use, and opening such facilities to the industry organization with an appropriate cost distribution would also be desirable to further promote a tri-organizational collaboration.

(2) Promoting practical application of research results

1) Standardization

In many areas of the information / communication sector, using R&D results as systemized or practical international standards (de-facto), thus enhancing the industry's competitiveness, is important. To this end, the government must actively promote private sector efforts and support standardizing work as much as possible.

2) Testbed

In an effort to promote information / communication technology's verification and R&D, a testbed should be developed that will lead to international standardization and application according to research themes. The testbed should facilitate swift and flexible R&D in information / communication technology. It should be designed specifically for R&D to make technological verification / standardization possible. If this condition is met, the partial use of real-life networks should be considered.

+ Testbed for technological verification / standardization

The system should be designed as close to the actual environment as possible under an appropriate role sharing between the public and private sectors.

+ Testbed for examining usage for general users

To enhance contents and reflect user opinions sufficiently, it is necessary to provide an opportunity / environment that facilitates active participation by as many users as possible (including the elderly and handicapped) together with low-cost IT terminals and enable an examination of realistic market needs, if offered as a fee-charging service.

3) Pioneering use of new technologies

The government should take an active initiative in using new technologies, wherever possible (e.g., electronic administration with advanced security technology), while paying full consideration to promoting generic technologies for higher cost awareness, supporting / fostering venture projects, and developing universal designs for ease of use.

(3) Researcher exchange / flow, human resource development, etc.

With the tri-organizational collaboration in mind, designating some universities / laboratories as research bases for the focal allocation of researchers and reviewing the educational / research structure of each institution, thus dramatically boosting the scale and quality of human resource development in the information / communication sector, is necessary. At the same time, researcher exchange among business, academic, and bureaucratic communities should be expanded. Assignment terms should be introduced to fluidize human resources for research. In addition, students should be offered increased opportunities for R&D experience through allowing the use of R&D funds to hire researchers (including graduate students). They should be provided with chances for receiving broader education on subjects such as marketing and intellectual property rights on top of their engineering education. Universities and laboratories should be evaluated not only by the number of theses generated but also by the characteristics of their respective categories. Educational abilities as well as research capacities should be taken into account when assessing universities and their teaching staff.

(4) Handling of intellectual property rights

The copyright environment needs to be improved for handling intellectual property rights of R&D findings and for promoting content usage / distribution.

(5) Studying the impact of information / communication technology on society

In studying how information / communication technology affects society, technology's positive side (digital opportunities, etc.) should be appreciated and be promote its use. Also, to fully enjoy the benefits, society itself should readily accept changes, making examining how the society should be in today's Internet society necessary.

(6) Coordination with the IT Strategy Headquarters and enhanced international cooperation

IT Strategy Headquarters sets the goal of turning Japan into the world's most advanced IT nation. With R&D being an essential element in achieving this goal, the Council for Science and Technology Policy and IT Strategy Headquarters need to establish close coordination.

According to the characteristics of R&D themes, business, academic, and bureaucratic communities must promote strategic international coordination so as to develop R&D bases and human resource accumulation systems and promote international standardization / technological transfers.

Figure 1:Social Changes Induced by Information / Communication Technology

Internet society (present -)

+ *PCs, workstations, mainframe computers, etc., of businesses, public organizations, and individual households are connected via the Internet. High-speed Internet services are proliferating gradually in homes across Japan, broadening the scope of social and economic activities using this technology.*
+ *Businesses are beginning to use mobile-phone-based Internet services.*
+ *The range of Internet content is broadening from digital text / still images to animated images, music data, etc.*

⇩

Ubiquitous network society (2005 -)

+ *All persons and organizations will be liberated from location constraints and exchange various information on a global scale via various IT equipment and ubiquitous networks so as to enhance intellectual creativity and conduct efficient socio-economic activities.*
+ *High-speed mobile terminals, etc., will allow businesses and public organizations to provide services to staff and users anytime and anywhere.*
+ *Home appliances and various other devices will have built-in IT equipment / IC chip assigned with fixed IPv6 addresses so that users can control such devices or gather information.*
+ *Information / communication systems will emerge, offering security, reliability and ease of use.*

⇩

Next-generation information / communication society (2010 -)

+ *Ultra-small portable computers will help spread advanced socio-economic activities.*
+ *IT equipment / IC chips will become embedded in all facilities and devices, providing mutual communication that will support human activities.*
+ *Computers and robots will begin understanding human intentions and requests and accept verbal instructions to conduct intellectual tasks.*

The direction of Japan

Internet proliferation lags behind, while mobile-phone-based Internet services have rapidly spread.

⇩

Readiness exists to accept mobile-phone-based Internet services

⇩

The nation has the potential to lead the world in achieving a ubiquitous network society.

Environment Field

1.Current Status of the Environment Field

(1)Current research status

The environmental focus has shifted from individual pollution issues to those requiring a domestic and international socio-economic approach toward achieving a “sustainable society” with little environmental load. Consequently, R&D in the environment field needs to develop into comprehensive research that grasps the overall picture, ranging from individual process studies, to analyzing phenomena, evaluating the impact, developing counter technologies and assessing applicability to society. Future R&D tasks also include integrating social, human and natural sciences, and developing a research structure that facilitates visionary and preventive projects.

(2)R&D issues requiring improvement

The following are some of the main R&D issues that need improvement in the environment field:

The government is not setting out its overall R&D approach, leaving individual ministries to conduct R&D separately. Focal R&D themes must be pursued through initiatives under a more integrated research mechanism, organized across ministerial borders.

There have been insufficient efforts to promote fundamental research (e.g., long-term continuous environmental observation) and improve intellectual research infrastructures. Systematic and continuous R&D investments are needed.

Environmental research in human and social science areas is insufficient (including environmental policy studies, environmental economics, ecological ethics, etc.). It is necessary to enhance R&D in these areas, and strengthen their coordination with environmental studies in the area of natural science.

There is a lack of timely supply in human resources for addressing various environmental research issues. It is necessary to boost specialized environmental education at postgraduate schools, etc., while promoting freer flow of human resources.

The government is not actively participating in international environmental research initiatives. It is necessary to foster human resources that can lead research in the international arena.

2.Areas of Focus

(1)Priority approach

In prioritizing specific fields or tasks we must take the following points into account, based on the perspective of international contribution.

Contributing to the resolution of urgent and significant environmental issues.

Assisting the development of a society that enables sustainable development.

Delivering a significant impact in improving the quality of living and in revitalizing the industry and economy.

Based on these perspectives, areas of focus have been defined as “R&D for resolving global environmental issues”, “R&D for comprehensive management of chemical substances”, “R&D for developing a recycling-based society” that are described in the second term basic plan, and “R&D for developing a eco-harmonic society”.

(2)Promoting R&D in tri-sector partnership

Since environmental issues involve complex and diverse association of phenomena, conducting research into individual aspects does not lead to effective resolutions. Recent environmental issues, in particular, are affecting greater areas and are worsening, raising the need to take a comprehensive new R&D mechanism beyond the conventional framework. In order to address areas of focus, individual research, conducted by separate ministries, should be brought together, reorganized in coherence, and promoted under government initiative with scenarios defining policy goals and a process for resolution.

(3)Priority tasks

Based on the propriety of the approach described above, priority has been given to five tasks. Of those, top priority is given in FY 2002 to R&D for global warming, R&D for waste-free / resource recycling technologies, and R&D for eco-harmonic regeneration of river basin and urban areas.

1 R&D for global warming

a) Objective

To conduct observations and predictions on global warming, assess the effects of environmental fluctuations (temperatures, sea level, etc.) on nature, the economy and society, and develop technologies for averting or minimizing their adverse effects.

b) Necessity for urgent prioritization

In the issue of global warming, there is a need for continuously implementing fundamental efforts domestically and internationally toward the objective set out in the UNFCCC (United Nations Framework Convention on Climate Change). Japan has a significant mission and responsibility in contributing to international frameworks such as IPCC (Intergovernmental Panel on Climate Change), which reviews the progress of the Kyoto Protocol that was adopted in COP3 (Third Conference of the Parties to the UNFCCC) in 1997, as well as cutting-edge scientific findings on global warming. This issue, therefore, has a high level of necessity and urgency compared to other issues concerning the global environment. We are also expected to contribute to IPCC in its preparatory work, commencing in 2002, to compile the Fourth Assessment Report (2006 onward) covering the issues on the stabilization level of greenhouse gases.

The cause and effect of global warming are profoundly intertwined with social and economic structures, and thus require a comprehensive approach covering a broad range of areas. The government must take the initiative in addressing issues of such significance. Japan, with energy-originated CO_2 accounting for about 80% of the nation's greenhouse gas emission, needs to develop and implement energy technologies as part of its R&D policy on countermeasures for global warming. At the same time, global warming and climate change, their effects and countermeasures, are factors mutually affecting each other, and consequently research on those must be coordinated and implemented in a structured fashion.

c) Research promotion and themes

The government initiative will include: (i) Comprehensive monitoring program for global warming, (ii) Research program for predicting global warming and climate change, (iii) Research program for assessing impacts and risks of global warming, (iv) Program for developing technologies to fix and sequestrate greenhouse gases, (v) Technological development program for controlling emission of greenhouse gases caused by human activities, such as energy generation (individual technologies in this program are also defined in the energy field) and (vi) Policy research program to control global warming. Individual projects of government ministries will be integrated under each of these programs, and promoted under industry-academia-government collaboration.

Program (i) will focus on enhancing the observation and monitoring system and its database, while Program (ii) will aim at achieving advanced climate change models based on individual process studies. Program (iii) will identify and predict the comprehensive effects of global warming, as well as developing application technology for averting or minimizing its adverse effects. Program (iv) will concentrate on developing technology for absorbing, separating, recovering and sequestering greenhouse gases, whereas Program (v) will work toward energy saving and new energy technology to reduce greenhouse gas emissions. Program (vi) will focus on assessing technologies used in countermeasures, compiling future scenarios in greenhouse gas emission, and exploring policies on how to best combine mitigation and adaptation measures.

2 R&D of waste-free, resource recycling technologies

a) Objective

To develop technologies and systems for a material-recycling society with a low environmental load for controlling resource consumption and waste generation, and for minimizing the environmental load.

b) Necessity for urgent prioritization

In order to ensure sustainable development of Japan's economy and society, we must implement the concept of 3R (Reduce, Reuse and Recycle), dispose waste properly and utilize nature's own recycling function, and develop a recycling-oriented society in which the consumption of natural resources is controlled and the environmental load is minimized. In 3R, technological strength contributes significantly to industrial and corporate competitiveness through cutting costs through environmental load reduction and by improving production efficiency and appropriate energy consumption. For this reason, planting new seeds of technology will not only help build a recycling-oriented society, but will also strengthen the nation's industrial competitiveness in the world economy. Transferring 3R technology to developing countries will also represent our major contribution to the world effort to develop a world-wide recycling-oriented socio-economic system.

In order to develop this recycling-based society, there should be a system in place for mutually coordinating individual technologies. Resource recycling, appropriate on an individual regional scale, should be established through increasing the applicability of recycling systems to local industrial structures and lifestyles. Since many products are now produced overseas, the efforts must go beyond national borders to coordination with overseas producers. Inappropriate and illegal waste processing and disposal continue to be reported frequently on an aggravating scale, accumulating a negative legacy such as contaminated soil and unsuitable disposal grounds. To provide a sense of safety and security, it is an urgent task to develop and utilize appropriate waste processing technologies, extend the life of processing plants and remedy the environment surrounding illegal waste dumping sites.

c) Research promotion and themes

The government initiative will include programs for (i) developing a support system for creating a recycling-based society, (ii) recycling technologies and systems, (iii) recycling-oriented design and production and (iv) technologies and systems for appropriate waste processing and disposal. Individual projects of government ministries will be integrated under each of these programs, and promoted under industry-academia-government collaboration.

Program (i) will focus on assessment through lifecycle assessment, material and energy flow analysis, etc., on future prediction methods, on developing technology for the introduction and promotion, and on building a system for maintaining contact with people's lives, which is where the movement toward a recycling-oriented society begins. Program (ii) covers technologies and systems for recycling automobiles, construction waste, organic waste, clothing, etc., and for promoting regional-based recycling advancement (social model verification, etc.). Program (iii) works toward developing design, construction and production technologies for reducing waste and for facilitating recycling and reuse, while Program (iv) works toward developing technologies for reducing waste and providing for its advanced recycling, introducing decomposition processing of waste containing hazardous materials, regenerating landfills, remedying contaminated environments and monitoring for inappropriate waste processing.

3 R&D for eco-harmonic regeneration of river basin and urban areas

a) Objective

To develop technologies for observing, diagnosing and assessing urban environments and ecosystems in river basin areas, and management models for river basin areas, in order to develop eco-harmonic urban communities. In addition, to develop technologies and methods for the regeneration and renovation of urban and river basin environments.

b) Necessity for urgent prioritization

Japanese cities have traditionally emerged and developed along rivers, founded on the natural circulation system of river water. However, the period of post-World War II economic growth led to a high concentration of population and economy in Tokyo and other coastal cities. These subsequently evolved into mega cities with increased water demand and contaminant discharge, causing significant strain on the environment of river basin communities. Consequently, the natural foundation for sustaining cities has collapsed, creating the need to preserve and remedy the environment of river basin areas as a whole. Efforts should also be made to improve the city environment, which is suffering from a high environmental load and reduced or jeopardized environmental systems, and to provide increased opportunities for people to connect with nature, thus delivering a "healthy", "safe and secure" and "comfortable" living environment in cities.

Given the present circumstances, we must recognize large cities as a component of river basin areas, and aim for shaping eco-harmonic cities, while controlling the sprawling expansion of urban areas, and establishing a structured and close relationship with other river basin areas. Water circulation, in particular, is the key factor in developing and transforming cities and ecosystems in river basin areas. Therefore, it is necessary to regenerate and renovate the natural and social environmental foundation, while defining borders systematically separating cities from surrounding communities to maximize the benefit of natural water circulation within river basin areas. To this end, we must work toward acquiring and systemizing scientific knowledge, and developing relevant technologies and systems.

Overall, it is necessary to implement and control data from continuous and comprehensive monitoring of river basin and urban environments, collect and organize related information, develop methods for comprehensive environmental management, and develop technologies for remedying jeopardized ecosystems, while designing and presenting scenarios for environmental regeneration suitable for individual cities or river basin areas, and conducting R&D toward practical regeneration and renovation technologies.

c) Research promotion and themes

The government initiative will include programs for (i) monitoring urban and river basin environments, (ii) developing the urban/river basin management model, (iii) developing eco-harmonic technologies, and (iv) preparing and implementing scenarios to create an eco-harmonic society. Individual projects of government ministries will be integrated under each of these programs, and promoted under industry-academia-government collaboration.

Program (i) will explore technologies for observing, diagnosing and assessing river basin ecosystems and the city environment from the perspectives of natural environmental foundations (water circulation, material circulation, biodiversity, etc.) and social environmental foundations (urban rivers, river basin areas, coast areas, etc.). Program (ii) examines the development of individual component models (e.g., water circulation model, ecosystem model) and a river basin management model integrating all component models, whereas Program (iii) focuses on water circulation and develops technologies for preserving the natural environment and for remedying deteriorated ecosystems (forests, farms, rivers, river basin areas, coast areas, etc.), as well as living space for humans. Program (iv) will concentrate on preparing a scenario for promoting the above measures, and on developing technologies for practical application.

4 R&D for comprehensive risk management of chemical substances

a) Objective

To develop methods for comprehensively assessing and managing risks involving chemical substances, and technologies for reducing and minimizing those risks.

b) Necessity for urgent prioritization

There is a heightening awareness, both domestically and internationally, of the risk of chemical substances. In developing a sustainable society, in which future generations can enjoy healthy living and an affluent environment with no anxiety over chemical substances, R&D on assessing and managing the risk of such substances has a significant role to play. Urgent action is especially needed against environmental endocrine disrupters with potential serious effects upon future generations, POPs now under tighter international regulations, and chemicals subject to data reporting obligations under the PRTR laws. Amidst international competition with European, U.S. and Asian countries, it will be essential for Japan to establish an innovative production technology system in harmony with the environment, in our effort to form a sustainable society.

People are exposed to chemical substances via environmental media (air, water, soil) and various other media including agricultural and fisheries produce, household appliances, tap water, and indoor air. Ministries must act in close coordination with each other in developing technologies for detecting chemicals, evaluating their toxicity and levels of exposure, making risk assessment, and taking steps toward the risk reduction and public communication.

c) Research promotion and themes

The government initiative will include programs for developing (i) risk assessment (ii) risk reduction technologies, (iii) risk management methods and (iv) intellectual infrastructures.

Program (i) develops innovative measuring technologies for detecting very small amounts of chemical substances, new methods in toxicity assessment, modeling technology for identifying and predicting chemical substance behavior, and risk assessment technology based on these technologies. Program (ii) focuses on establishing a production technology system in harmony with the environment, potentially minimizing by-products and waste. It also explores technologies for converting by-products into non-toxic forms, remedying and defusing contaminated soil, drainage and deposits, and reducing hazardous emissions. Program (iii) aims at systemizing knowledge for achieving an information system for chemicals control and promoting risk communication, whereas Program (iv) focuses on improving more fundamental areas such as developing and preserving standard experimental organisms and preparing a specimen banking system.

5 R&D for global water circulation changes

a) Objective

To project the global supply and demand of water resources, project changes in water circulation and their impact from the natural and social perspectives, and to develop the optimum water management method on an international scale.

b) Necessity for urgent prioritization

Water-related problems, such as water shortage, water contamination, and flooding, have been reported in increased numbers across the world, especially in developing countries. These factors are creating a growing impact, including food shortages and epidemic outbreaks. These phenomena are attributed to rapid population growth, urban development, and industrial development, with water-related international conflicts already occurring in various parts of the world. With the world population set to increase, the situation is expected to deteriorate further. For this reason, the water issue is expected to become one of the biggest global environmental issues of the 21st century. With the Huang River (Yellow River) drying out before reaching the sea and the Chang River flooding, human activities are already altering water circulation systems. In affected areas (especially Asia), Japan, with its advanced economy and technology, must provide scientific expertise and the technological foundation required to enable effective and efficient water management.

This government initiative is expected to broaden Japan's technological contribution to other Asian nations, which share similar natural and social characteristics. It represents R&D for international application, with a focus on averting negative impact on Japan through resolving water problems in other countries.

c) Research promotion and themes

The government initiative features programs for (i) observing global water circulation, (ii) developing the model of water circulation changes, (iii) assessing the impact on human society, and (iv) making a comprehensive evaluation of countermeasure scenarios and technological development. Individual projects of government ministries will be integrated under each of these programs, and promoted under industry-academia-government collaboration.

Program (i) focuses on enhancing the observation and monitoring system, and developing a database. Program (ii) is aimed at resolving the natural mechanism of change in energy transfer and water circulation, and developing a prediction model for changes in water circulation and the environment due to human activities. Program (iii) assesses the impact of water circulation changes on food production, society and the economy, whereas Program (iv) presents the optimum scenarios for countering water-related problems.

In addition to the above research tasks, the following two tasks are important in promoting environmental studies:

6) Intellectual research infrastructure in the environment field

In order to ensure smooth environmental studies and appropriate proliferation of environmental technologies, it is important to systematically develop intellectual and research information infrastructures in environmental science and technology, including standard materials, environmental reference samples and data, biological resources, environmental monitoring, environment-related statistical data and database, methods for assessing environmental technology, and information systems for environmental research and technology.

7) Promotion of pioneering research

Pioneering research involves discovering the fundamentals of environmental issues before they become socially manifest, and developing new research methods from unrestricted perspectives including academic areas that are not usually applied. Pioneering research should be promoted, in which emphasis must be placed on achieving a fundamental understanding and resolution of environmental issues, and exercising creativity in the process.

3. R&D Targets in Focal Areas

(1) R&D for global warming

1) Overall target

According to the goals set out in the Framework Convention on Climate Change, the target is to acquire and systemize scientific knowledge, develop new and advanced technologies for countermeasures, and to draw up a scenario for bringing global warming under control on the basis of acquired knowledge in order to investigate the possibility of controlling greenhouse gas emission so as not to cause crisis to human beings and ecosystems.

2) Targets of individual programs

a) Comprehensive monitoring program for global warming

To develop a monitoring system for the Asia-Pacific region to halve the uncertainty over the estimated amount of CO_2 absorbed or released in marine and land areas, and to detect climate changes with a high degree of sensitivity. Also, establish a cooperative international network for accumulating, providing and using data.

b) Research program for assessing impacts and risks of global warming

To identify the mechanism of global environmental changes needed for model development and enhance the precision of models for predicting greenhouse gas concentration and climate change, so as to enhance models for future climate change prediction including tendency changes in abnormal weather conditions.

c) Research program for assessing impacts and risks of global warming

To make a comprehensive assessment of the impact of global warming, encompassing the entire

Asia-Pacific region with a focus on Japan, clearly define future impact and risk, and devise measures for averting such risks.

d) Program for developing technologies to fix and sequestrate greenhouse gases

Toward the goals set out in the Framework Convention on Climate Change, to develop technologies for increasing CO_2 absorption into ecosystems (forests, etc.), and separating, collecting, sequestering and reusing CO_2 contained in exhaust gases, etc.

e) Technological development program for controlling emission of greenhouse gases caused by human activities, such as energy generation

Toward the goals set out in the Framework Convention on Climate Change, to develop technologies for reducing CO_2 through energy savings and new energies, and cutting down the emission of other greenhouse gases.

f) Policy research program to control global warming

Present the scenario for controlling global warming, taking into consideration socio-economic trends, the uncertain nature of climate change predictions, the impact and risk of global warming, and the potential of technological innovation for mitigation.

(2) R&D of waste-free, resource-recycling technologies

1) Overall target

To develop technologies and systems contributing to reducing waste, improving the recycling rate, and lowering environmental risks from hazardous waste.

2) Targets of individual programs

a) Program for developing a support system for creating a recycling-based society

Based on the principles of hierarchical material circulation and low environmental load, to develop LCA methods, etc., for properly evaluating the technologies and systems needed to form a recycling-oriented society.

b) Program for developing recycling technologies and systems

To achieve advancement and practical application in recycling technologies and systems for individual circulating resources, and to seek enhanced efficiency, advancement and application of vein logistics as the foundation for recycling systems.

c) Program for developing recycling-oriented design and production

To develop design, construction and production technologies that enable industrial products, food circulation resources, constructions, etc., to embody 3R in the design and production stages.

d) Program for developing technologies and systems for appropriate waste processing and disposal

To develop technologies and systems for addressing the urgent task of dissolving shortage of final waste landfills and inappropriate waste processing, and dissolving negative heritage , including disused products, illegal dumping, and contaminated land caused by inappropriate waste processing.

(3) R&D for eco-harmonic regeneration of urban and river basin areas

1) Overall target

As a contribution to drawing up specific plans to achieve a eco-harmonic society in major cities and river basin regions, to develop systematically technologies and systems for regenerating such areas, and to design and present a scenario for achieving eco-harmonic cities while controlling the sprawling expansion of urban areas.

2) Target of individual programs

a) Program for monitoring the urban and river basin environments

To make a comprehensive observation and diagnosis of the environment, including the condition of water and material circulation and ecosystems, in model cities and river basin areas including urban, agricultural, mountain and fishing communities. Also, to collect past and present data from across the nation on urban and river basin regeneration and management, and develop a comprehensive data system on the environment.

b) Program for developing the urban and river basin management model

Based on identifying the processes associated with changes in water and goods circulation, ecosystems, etc., of river basin communities including urban, agricultural, mountain and fishing areas and analyzing human activities in such areas, to develop models for predicting environmental change, make impact assessments and develop an integrated urban and river basin community management model.

c) Program for exploring eco-harmonic technologies

To develop eco-harmonic technologies and systems for preserving a good natural environment in river basin communities including urban, agricultural, mountain and fishing areas, remedying jeopardized ecosystems, and improving deteriorated living space.

d) Program for preparing and implementing scenarios for the creation of a eco-harmonic society

To present basic concepts of social systems, i.e. human activities essential to developing a eco-harmonic society in river basin areas including urban, agricultural, mountain, and fishing communities, and to design and present technological and policy scenarios concerning remedying and regenerating the environment.

(4) R&D for comprehensive risk management of chemical substances

1) Overall target

To define subject chemical substances in those which require urgent risk management (e.g., substances subject to PRTR), and develop the technological foundation, knowledge structures, and intellectual foundation, for comprehensive management of chemical substances to ensure “safety and security”. Based on the results, to develop a system for risk assessment and management that facilitates communication of the risk associated with the subject chemical substances across the social hierarchy within 10 years (by 2012).

2) Targets of individual programs

a) Program for developing risk assessment systems

To achieve efficient prediction and monitoring, and to improve the technologies for exposure assessment, and hazard assessment to humans and ecosystems, using innovative measuring technologies and environmental behavior modeling. To systemize the acquired knowledge to facilitate priority evaluation of risk reduction, and to set a direction toward accurate risk minimization so as to develop comprehensive technologies for effective and efficient risk assessment.

b) Program for developing risk reduction technologies

To establish technologies for reducing discharge of chemical substances, develop the foundations of environmentally friendly production technologies, and establish a system for best available technologies. At the same time, to establish the basic fundamental technologies for remedying and detoxifying chemical contamination of the environment (soil, underground water, deposits).

c) Program for developing risk management methods

To build an information system to support the comprehensive management of chemical substances through systemizing scientific knowledge on chemicals. Also, to develop social and policy risk management methods including a systemized knowledge base for risk communication.

d) Program for developing intellectual infrastructures

To develop a data storage and management system and to develop and preserve standard experimental organisms, while building a system for preserving acquired samples so as to create a specimen banking system that can disseminate information to the world.

(5) R&D for global water circulation changes

1) Overall target

To present scientific knowledge and a technological foundation for establishing water management methods for averting or minimizing the adverse effects of changes in water supply, demand, and circulation, and facilitating sustainable development into the future. Based on this knowledge and foundation, to propose optimum water management methods for the Asian region.

2) Targets of individual programs

a) Program for observing global water circulation

To promote systematic observation activities (satellite observation, marine observation, land surveys and monitoring, etc.) and develop a global system of water circulation observation to enable mutual use of observation data. Also, to promote the accumulation of data in Asian monsoon areas, etc.

b) Program for developing the model of water circulation changes

To develop a model for projecting water circulation changes associated with fluctuations in water supply and demand and with climate changes. Also, to create a scenario for analyzing the trends of human activities that affect water circulation, so as to form the basis for a model capable of projecting water circulation changes and accompanying environmental changes.

c) Program for assessing the impact on human society

Based on the projection of water circulation changes and accompanying environmental changes, to make a quantitative assessment of their impact on food, water resources, ecosystems, human health, society and the economy.

d) Program for making a comprehensive evaluation of countermeasure scenarios and technological development

With the objective of achieving optimum water management, to make applicability assessments of existing technologies, develop new technologies, and present countermeasure scenarios.

(6) Intellectual research infrastructure in the environment field

To enhance and advance intellectual infrastructures for environmental research to a level where broader usage is possible.

(7) Promotion of pioneering research

To develop innovative knowledge and new research paradigms for resolving environmental issues.

4.Basic Issues for Promoting R&D

(1) Priority issues for improving the quality of R&D

1) System for promoting and evaluating the initiative

To enable efficient and effective promotion of the initiative and of individual programs or projects, the Council for Science and Technology Policy must exercise strong leadership in building a mechanism that defines the responsibilities and authorities of each level, and establish an evaluation system whereby appropriate evaluation and assessment results are reflected in resource distribution, etc.

2) International cooperation

With the key environmental tasks having shifted to domestic and international socio-economic activities, international cooperation is essential to promote scientific and technological research into the environment. For this reason, priority research must be conducted effectively and efficiently, pursuing the possibility of international cooperation with the United States, Europe, etc. Cooperation with developing countries should also be promoted from the perspectives of human resource development, ability enhancement, etc.

3) Proliferation of R&D

Priority tasks should be conducted toward the clear goal of contributing to the resolution of environmental issues. Research findings must be actively reflected in environmental policies, and a system for facilitating this needs to be developed. Also, efforts should be made to help the general public understand the necessity of R&D and to win their cooperation, so that they can see and work toward the future with a sense of security.

4) Tri-sector partnership and role distribution

In the environment field, the scientific knowledge and technology of various fields are combined together according to social needs. This makes it extremely inefficient and unproductive for a single entity to handle all aspects of R&D. Public sector or academic laboratories should take charge of themes that do not conform to the market principle, themes involving high risks or costs in research investments as well as more basic or fundamental themes, whereas the private sector should take the initiative in applied research for practical application. Based on this approach, we must promote R&D and technological proliferation under partnership and role distribution among industry, academia and government.

5) Coordination with local initiatives by regional governments, NGOs, etc.

Environmental problems arise according to the state of each region's natural environment, society and economy. In exploring themes with regional characteristics, it is therefore effective to strengthen ties with regional governments and university laboratories that conduct R&D on region-specific environmental issues, or with private enterprises, NGOs, etc., that are actively addressing such problems.

(2) Resources required in R&D

1) Enhancement and expansion of competitive funds

Competitive funds must be further enhanced and expanded to broaden research fund options and develop a competitive R&D environment, thus enabling the smooth implementation of research in pioneering areas, or the addressing of emergency situations.

2) Human resource development

In order to promote environmental research effectively and efficiently, it is important to secure and develop human resources in addition to expanding research funds. We must enhance the domestic and international research networks of independent administrative institutions, universities, and environmental research institutes (private or regional government affiliated), while introducing more flexible research systems, a fellowship system, and an invitation system for overseas researchers. In addition, we must support the effective use of museums, NGOs, and other organizations with a high potential, as well as newly established or reorganized universities and postgraduate schools focusing on environmental studies, while actively seeking to use the human resources provided by such organizations.

3) Coordination with other fields

The environment field typically consolidates methods and technologies from various other fields according to social needs and demands. Therefore, the trends of new methods and technologies in other fields must be observed and actively applied to the environment field, so as to create a new paradigm in environmental studies.

4) Developing large facilities dedicated to environmental studies

It is necessary to develop large-scale experimental facilities capable of reproducing various environmental conditions, to acquire the world's cutting-edge analysis devices, and to prepare outdoor research facilities for long-term and continuous observation.

Nanotechnology and Materials

1. Current Status of Nanotechnology and Materials

1.1 Trends and characteristics of the field

While R&D in nanotechnology has been steadily progressing on a broad base in Japan, recently, other countries are also promoting the field under strategic initiatives. Unfortunately, Japan's potential in the field is not being fully utilized because we are lagging behind in basic, fundamental and collaborative R&D, and in applying basic findings to devices and systems.

Materials industry has created employment and supported economic development in Japan, producing ripple effects throughout various industries. Technologically speaking as well, materials research has served as a basis for innovations in variety of fields. Recently, Japan is demonstrating competitiveness not only in material processing technologies, but also in advanced functional materials that require continuous innovations. Many technological improvements are being made through research activities seeking for the best combinations of materials and processes to achieve particular objectives.

Followings can be listed as common characteristics throughout the field of nanotechnology and materials. First of all, results obtained in basic researches could be promptly commercialized as final products. Secondary, innovations in instrumentation, evaluation, and processing techniques have wide effects in the overall field. Finally, whatever the stages of R&D are, there exist possibilities to achieve great discoveries and inventions, and those discoveries and inventions may possibly create major changes in society's approaches toward goods and services.

1.2 National and societal demands and challenges in technological innovations

1.2.1 Strengthening industrial competitiveness and sustaining socioeconomic development

In order to respond to issues such as stagnation in hiring power and decrease in industrial competitiveness that are caused by intensification of international competition and economic globalization, it is necessary to strengthen Japan's industrial competitiveness and firmly build the foundations for socioeconomic development, through development of the 21st century-type key technologies.

Currently, there are increasing prospects for the field of nanotechnology and materials to shift rapidly towards a new paradigm and a new technological wrinkle. As present socioeconomic issues should be overcome through technological innovation, the innovations in the current field are said to influence the fate of various technological fields. Therefore, it is indispensable for us not to merely apply symptomatic therapy-type measures to the present socioeconomic issues, but rather to solidly ground ourselves in setting up the field as a foundation to establish the groundwork for sustainable growth in the future.

1.2.2 Realization of abundant lifestyles through measures for environment/energy and for aging and low-birth-rate society

To attain fundamental solutions for the various issues brought about by our materialistic society, such as lack of energy/resources and global environmental problems, a fundamental revolution of current mass consumption society is required. Influences to environment should be considered from the initial stages of R&D activities, not just by after-the-fact measures, and it is important to develop environment-conscious products from a material level.

In the 21st century we may confront aging and low-birth-rate society. In order to achieve comfortable and worthwhile lives even in the society, it is necessary to build societal systems that enable us to live self-directed and self-reliant lives. Breakthroughs in revealing and utilizing life mechanisms are required to improve levels of detection, treatment, and prevention of illness and thereby improve expectancy in healthy life. At the same time, it is necessary to incorporate these breakthroughs into our daily lives in forms that are highly harmonious with our society and bodies. For these purposes, it is necessary to develop following methods and materials and provide them in form of medical systems.

Methods to study human body in molecular level

Methods to deliver necessary amount of drug to necessary places and to conduct disposal to the necessary extent

Biocompatible materials

1.2.3. Realization of sound development of Japan from viewpoint of national security, such as securing safe/comfortable life and retaining strategic technology

Measures should be prepared against viruses from overseas, risks from harmful chemical substances, and threats from terrorisms those employ novel chemical and biological substances. To deal with these issues, it is important to establish risk management systems, which enable to detect harmful substances in various stages in our daily lives. Therefore it is indispensable to establish risk reduction/elimination methods by developing and systemizing detectors for minute substances and by developing innovative catalyst technologies.

In recent years, cross-boundary R&D and other international activities are becoming everyday events. In such a world, it is necessary for Japan to maintain competitiveness, by setting up R&D environments that enhance to develop advanced key technologies and that allow such technologies to emerge easily.

2. Areas of Focus

2.1 Priority approach

In the 21st century, it is necessary to achieve a culturally/spiritually rich society, not merely material and economic wealth by pursuing further technological innovation. Therefore, it is indispensable for the field to perform R&D to further reveal fundamental principles governing the nature and materials.

By taking the above mentioned and the following two points in account, priorities of the field are set to R&D areas aimed to overcome national/societal issues and to the basic research areas aimed to study materials and other fundamental science/technologies.

Points described in the S&T basic plans, such as to distribute certain amounts of resources to innovative researches.

Clearly distinguish research themes, which aim for practical application in 5 to 10 years and in 10 to 20 years.

2.2 Prioritized areas

Nanodevices and novel materials for next generation IT systems

Novel materials for environment conservation and efficient energy consumption

Nanobiology based on biological mechanisms, and microsystems and novel materials for medical use

Basic technologies such as instrumentation, evaluation, processing, numerical analysis/simulation, etc.

Innovative materials with advanced physical properties and/or functions

3. R&D Targets in Prioritized Areas

3.1 Nanodevices and novel materials for next generation IT systems

Achievement objectives:

Secure international competitiveness in high-speed, highly integrated and low energy consumption electrical devices, which support advanced and global IT society
Examples of technological objectives:
Development of semi-conductor processor and/or memory devices utilizing 1/2 the current line width
Development of storage systems with 10 times the current density.
Development of optical transmission systems that can carry 30 times the current load
Develop new-concept devices through competitive R&D
Examples of technological objectives:
Demonstration of device operations utilizing various new-concept circuit elements of nanometer sizes
Development of basic circuit elements for quantum information transmission and their systemization.

It is necessary to aim for practical application and industrialization within five to ten years for information storage and semiconductors, by employing measures that emphasize R&D speed and market impact. Therefore, we must engage in R&D with close industry-academia-government collaborations. Particular importance must be placed on devices and materials, production designs, and manufacturing technologies.

At the same time, looking forward for ten to twenty years, foundations of new concepts devices should be established in coming five years. During this term, it is necessary to set up objectives and promote R&D activities competitively by accounting roadmaps of various new-concepts devices and their actual form of use. Therefore, to acquire next-generation advanced mission-critical technologies, it is necessary to promote researches by applying competitive-type research funds as the base. Furthermore, it should be emphasized that even in this basic research term, R&D must be promoted considering systemization of the individual devices.

3.2 Novel materials for environment conservation and efficient energy consumption
Achievement objectives:
Develop novel materials for comprehensive CO2 emissions-reduction to achieve COP3 targets and incorporate the materials into our everyday life.
Develop novel technologies for reducing chemical risk and pollution for a safety life and incorporate the technologies into nation's life and society.
Examples of technological objectives:
Development of low cost (1/2 the production cost of current module) photovoltaic cells with high-energy conversion rates.
Development of metal materials with improved thermal strengths and/or corrosion resistance to be used in thermal power plants and thereby reduce CO2 emissions by 30%.
Development of technologies that enabled to detect ppb level substances easily.
Establishment of chemical risk reduction technologies focusing on substances listed on the PRTR Law.
Promotion of prediction-oriented R&D based on computer simulation methods incorporating environmental risk information of existing substances.

In the initial stages of developing novel materials, it is important to apply prediction-oriented R&D methods employing computer simulation, which incorporates basic data of the environmental risks of existing materials. Furthermore, R&D should be evaluated by not only from the scientific viewpoint but also from a wide perspective that encompasses societal aspects as well.

Additionally, we need to promptly establish a framework to assess risks on environment and society that are caused by newly invented chemicals, and to develop technologies that can reduce these risks. It is also important that the framework is organized so that citizens can manage and give their assent to.

3.3 Nanobiology based on biological mechanisms, and microsystems and novel materials for medical use

Establish material seed technologies, which can be applied for regenerative medicine and for targeted therapy to extend healthy life expectancy.

Examples of technological objectives:

Verify safety for applying microsystems to medicine which allow diagnosis and treatments with low invasion level

Reveal fundamental principles of biological structure and biological mechanism to construct highly efficient and integrated systems.

Examples of technological objectives:

Establishment of technologies to measure and analyze statistic and dynamic structures/responses of single protein molecules and their super-molecular complexes.

Establishment of methods to chemically bond optional functional groups onto necessary sites of protein molecules utilizing their 3D structural information.

Development of basic technologies to establish highly efficient energy transfer microsystems by applying biological reactions

Development of basic technologies for super-parallel processors and super-large-capacity intelligent memories utilizing biomimetic data-processing methods.

It is necessary to build bridges between medicine, engineering and science to promote R&D in microsystems and biomaterials aimed for medical uses. Looking forward for the practical applications on the horizon in ten to twenty years, currently, it is essential to carry out the researches by setting up an environment to establish organic alliances among various disciplines. Therefore, following points should be emphasized in promoting the researches; development of human resources, promotion of industry-academia-government collaborations from an early stage of R&D, and promotion of tests to substantiate the technology in society prior to the actual stage of use.

We must develop methods and technologies for integrating proteins into high-order structures, and methods to bond optional functional groups onto the necessary sites of protein molecules based on their 3-dimensionl structural information. Thereby, it will become possible to develop technologies to solve in mid-term objectives, such as to measure and analyze static structures and dynamic responses of individual protein molecules and their complexes (super-molecules), to construct microsystems for medical/industrial use, and to applying them to various industrial processes. In order to seek future application in devices, industrial processes and others, it is necessary to promote industry-academia-government collaborations from the early stages of R&D activities.

3.4 Basic technologies such as instrumentation, evaluation, processing, numerical analysis/simulation, etc.

Achievement objectives:

Develop high-precision instrumentation, evaluation, and processing technologies that have one order higher precisions than those required in R&D.

Utilize computer simulation methods in developing novel devices and materials.

Examples of technological objectives:

Development of semiconductor processing technologies that achieve 1/3 the current line width

Link microscopic and macroscopic simulation algorisms seamlessly and utilize them in actual R&D sites

Double the number of microscopic measurement standards compared to that of the present

In this area, it is necessary to pursue the limits of evaluation, processing and other technologies. Also, since achievements in the area have large ripple influences on various R&D activities from basic to application, it is necessary to distribute resources steadily.

In addition to above, measuring standards and standard substances to calibrate apparatuses used instrumentation and processing should be developed, because these apparatuses are required to possess one order higher precisions compare to those of the objects to be measured or processed. Furthermore, it is necessary to establish foundations for bottom-up type techniques to look ahead for nanolevel processing in the future, in addition to further pursuing the limitation of the current top-down type techniques.

3.5 Innovative materials with advanced physical properties and/or functions
Achievement objectives:
Develop various materials that breakthrough current barriers by R&D in nanolevel with strategic and expansive perspectives
Construct novel research methods and production processes to accelerate R&D and their application in providing solutions to societal issues
Examples of technological objectives:
Development of construction materials having lifetime and strength, which are twice as high as those of the current.
Development of materials for electric field radiation devices with external quantum efficiency, which is twice as high as that of the current.
Shortening time need to develop catalyst by 1/10 compared to that of the current, by applying the combinatorial method to development
Enhancement of a substance database (1.8 million items by 2010)
Diffusion of R&D support tools use such as computer simulation methods.

It is necessary to develop devices and parts, which fully utilize the characteristics of materials, by integrating materials and their processing technologies. This can be achieved by performing R&D in materials and their processing methods simultaneously, and by controlling compositions and functions of the materials in nanolevel.

It is important to have approaches to realize unprecedented functions through measures that breakthrough classification of the current materials science; e.g. metal, inorganic and organic. Furthermore, it is crucial to perform R&D not solely on the basis of experiential knowledge, but by applying various support tools extensively such as computer simulation.

In addition, it is required to develop material database steadily, which summarizes information on material properties and processing conditions.

4. Basic Issues for Promoting R&D
4.1 Promotion of competition in/among R&D sites and measures to enhance competitive R&D environments
4.1.1 Importance of competitive-type research funds for demonstrating creativity

Except for the cases where fixed R&D methods exits and/or the case where R&D resources should be focused, such as in R&D of semiconductors, basically it is important to promote R&D through competitive-type research funds so that researchers can perform the most of their creativity.

4.1.2 Promotion of R&D that goes beyond frameworks of the ministries

One proposal is to establish research units (on comparatively large tie-up units) that go beyond the frameworks of individual ministries, and allocate resources to the units at the discretion of their organizers. Alternatively, it is necessary to set up functions, which can totalize the systems of each ministry from a broad perspective.

4.1.3 Incorporation of users to R&D evaluations

R&D should be evaluated not only from scientific viewpoint. However, it is important to utilize the evaluation processes so that the researchers can consider the appropriateness of their inventions. Therefore, not only experts, but also users of the inventions are highly recommended to incorporate thoroughly in the evaluation procedures.

4.1.4 Environments for improving R&D levels

a) Strategic initiatives for intellectual property rights

It is necessary for public research institutes to obtain intellectual properties strategically. Furthermore, it is necessary to develop human resources, who excel at managements and legal works so that the intellectual properties can be managed thoroughly in the institutions.

b) Measures towards international standards

Measures for obtaining and creating international standards should be promoted actively so that R&D results, such as newly developed materials, can be smoothly commercialized and reliabilities of the users can be secured. It is particularly important to have initiatives for making international standards for R&D procedures, test and evaluation methods (initiative such as a joint international research on test and evaluation to strength international influences).

c) Provision of intellectual foundation

It is necessary to develop intellectual foundation, including networks, according to the plan, and to implement them in various research areas, in order to improve the fundamental strength of researchers and to avoid overlapping in R&D investment. Particularly, the networks should be established so that they are user-friendly and easy to maintenance. In the field of nanotechnology and materials, particular efforts should be placed to provide the followings.

Databases of material and substance properties

Measuring standards and standard substances to determine characteristics, structures and/or composition in nanolevel

4.2 Promotion of collaboration among R&D fields and researchers

4.2.1 Promotion of collaborative and/or interdisciplinary R&D

Interdisciplinary approaches that fuse methods and systems of various academic fields, and joint researches that bring researchers with different scientific backgrounds together should be promoted in appointing R&D projects.

4.2.2 Establishment of basic environments for promoting collaborative R&D, such as to built networks among researchers and institutions

First of all, it is necessary for individual researchers themselves to actively build layers of personal networks on a daily level in each of their respective surroundings. However, to support researchers' efforts for constructing the personal networks, it is also important to promote measures to build networks among researches and research institutions.

Networks for exchanging and sharing research information should be developed taking the following points in account; openness, merits for information provider, and public involvement. To keep the contents up-to-date, we must also consider the costs for maintaining and updating the information and the facilities.

Large-scale facilities (e.g. synchrotron radiation, supercomputers etc.) used for atomic/molecular level structural and dynamical analysis, should be opened to public researchers in forms of joint use and remote use. Therefore, measures should be taken to promote public use by providing information and thereby improving user's convenience. Furthermore, public research institutions should plan to develop their new facilities based on the premise that the facilities are going to be opened to public researchers in advance.

4.2.3 Establishment of R&D centers for creative R&D

In the field of nanotechnology and materials, competitive relationships between several research centers are one of the features to improve creativity. Therefore setting up a central research institution is not always a good solution.

Rather than providing a new central center, it would be more practical and appropriate to adapt effective and efficient systems to existing institutions. In view of the characteristics that nanotechnology and materials are based on knowledge accumulated in various fields and disciplines, it is important for research managements to make the most use of collaborative and interdisciplinary approaches. Furthermore, it is necessary to strengthen the coordinating functions that build networks among appropriate research centers according to R&D objectives.

4.2.4 Promotion of systematic personnel exchange and incorporation of successes in researches promoted by the exchange into personnel evaluations

Collaborative R&D should be promoted by conducting personnel exchanges between institutions, not just by guiding R&D activities through incentives for collaboration, so that researchers having different scientific backgrounds can exchange their knowledge mutually. At the same time, efforts to conduct researches by personnel exchange and successes of those researches should be positively reflected in distribution of R&D funds and in evaluation of personnel performance.

4.3 Collaboration and role distribution between industry, academia, and government to build scheme for industrialization

4.3.1 Building scheme for industrialization

a) Speeding up technology transfer

Nanotechnology and materials is characterized as a field that results obtained in basic researches may be directly commercialized. Therefore, it is indispensable to build schemes to rapidly and smoothly transfer the results into industries. This can be said, not only for researches aimed for immediate industrialization, but also for fundamental and basic researches. To enhance the technology transfer, it is important to provide a wide variety of schemes for the transfers, and these schemes should be managed flexibly. Intellectual properties should be systematically managed in R&D institutions as well.

Furthermore in universities, it will be effective to aim for cross-cultural synergy by letting researchers to cooperate with management/business majors during R&D, so that the former can obtain entrepreneurial spirit and the latter can learn about practical methods.

b) Verifying R&D results by societal experiment

It is important to improve user acceptances of newly created materials and devices through societal experiments, and feedback the responses from society into R&D (reaffirming societal demands).

c) Utilizing procurement by government and public research organizations

It is important to procure pre-commercialized R&D results effectively and actively in public services and societal trial initiatives. Procurement standards to increase incentives for R&D-type venture enterprises to tender procurement should be also considered.

4.3.2 Promotion of industry-academia-government collaboration

a) Enhanced support for industry-academia-government collaborations

Universities and other public research institutes is the significant supplier of scientific/technological resources and knowledge. Therefore, for strategic and advanced R&D fields such as nanotechnology and materials, it is important for industrial sphere to increase collaboration with academia and governmental institutions. In particular, there are expectations from industries for universities to elucidate relationships between functions, structures and processes of materials, which industries tend to regard as “black-box” characteristics. On the other hand, from the viewpoint of securing accountability to taxpayers from universities, there are necessities for mutual collaboration between industry and academia in order to fully bring R&D returns to society.

Therefore, in addition to interdisciplinary initiatives, it is necessary to have enhanced support for industry-academia-government collaborations, which aim for practical applications and development of novel production technologies.

b) System reformation to enhance fluidity of human resources

To enhance industry-academia-government collaborations, it is indispensable to create environments so that individual researchers can perform their abilities thoroughly. One of the possible ways for enhancing the abilities is to improve fluidity of the researches by temporarily shifting them across research institutes, by letting them leave their original posts, and/or by assigning them multiple posts. However, in Japan, due to its long-cultivated social structure and sense of values, it is extremely difficult to alter societal framework overall to enhance human fluidity. At the very least, it is necessary to provide an environment, from a viewpoint of R&D system, which does not alienate people who take action with enthusiasm.

c) Increase incentives for industry-academia-government collaborations

It is necessary to provide guidelines for universities and public research institutions for entering into joint research contracts with industries, in order to secure transparency and to predict possibilities from the viewpoint of industrial sphere. In addition, it is required to allow more flexibility in utilizing private research funds in universities and public research institutes, so that the funds can be used much freely and rapidly and thereby increase incentives for the researches in universities and public research institutes to collaborate with industries.

Industry, academia, and government must work together toward equal partnerships so that researches do not have to concern about their backgrounds during the collaboration, by removing inherent obstruction and unfairness existing in individual institutions.

d) Evaluations of researchers involved in industry-academia-government collaborations

Experiences in industry-academia-government collaborations should be thoroughly implemented as one of the standards for evaluating researchers.

4.4 Development of human resources

4.4.1 Development of researchers

Enhanced supports are required to expand the human resources available for the world's top level R&D and various collaborative R&D. In addition, it is necessary to supports PhD students, post doctorial researchers and young researchers, so that they can be involved in high quality research activities.

4.4.2 Enhancement of research supporters

It is necessary to have proficient skills in order to operate the equipments for handling micro-scale and nano-scale areas. Therefore, measures to develop and pool experienced research supporters and to accumulate their know-how are highly required.

4.4.3 Development of human resources with abilities to manage and/or evaluate research projects

4.5 Points to be considered in promotion

1. Flexible and mobile measures adaptable to changes in R&D situation
2. Promotion of international cooperation, which can secure researchers, complement Japan's original technologies, and improve R&D speed.
3. Accountability to society and societal responsibility of researchers.

Energy Field

1. Current Status of the Energy Field
   (1) Current status of energy issues (basic target: simultaneous achievement of the 3Es)

Energy represents the foundation supporting people's lives and economic activities, yet Japan's energy supply structure remains feeble. Among industrialized economies, Japan has one of the highest levels of dependency on imported energy, with the primary energy source, oil, being imported mostly from the Middle East. In view of the increasing energy demand across the world, especially among the developing countries, it is unclear whether Japan can continue to receive a stable supply of energy. Also, energy is the primary source of greenhouse gas emission, and therefore needs to be the subject of measures to address global warming. Market liberalization is putting cost cutting pressure on energy suppliers, thus contributing to Japan's economic growth. In other words, the energy field is under pressure to achieve the three 'E's - Energy Security, Environmental Conservation and Economic Growth simultaneously.

   (2) Science and technology (S&T) in energy issues (coordination with energy policies and the three perspectives)

Energy issues cannot be resolved unless we strongly promote combinations of various policies and approaches. Policies on systems and the economy alone cannot lead to simultaneous achievement of the 3Es. Science and technology (S&T) plays an important role in the energy field, with S&T breakthroughs being needed to provide new technological options. Yet, S&T does not offer all the solutions. Given the full acknowledgement of their effects, limitations and problems, we must combine new technological options with other policies and approaches in seeking effective solutions. In this sense, it is essential in the energy field to coordinate between energy policies and the development of S&T.

In terms of S&T contributions to energy issues, it is essential to consider the following perspectives in addition to the achieving of the 3Es. The first perspective is safety and security. S&T, applied to the energy field through R&D, must provide both safety and security to the public.. Energy issues cannot be solved unless new technologies are accepted with social understandings, by achieving public accountability. The second perspective is international competitiveness. S&T is expected to contribute to efforts to enhance international competitiveness and to create business and employment opportunities. This perspective is important for achieving a goal to build a nation that is internationally competitive and capable of sustainable growth. The third perspective is international cooperation and contribution. Energy issues cannot be solved by Japan alone. For example, energy problems experienced in Japan cannot be truly solved unless they are also addressed in neighboring regions, including other Asian countries. In this sense, cooperation and contribution to the international community are essential for Japan to achieve the 3Es. Participation in international joint R&D is also important, both for efficient conduction of R&D and for becoming a nation capable of creating and utilizing knowledge, thus contributing to the world.

2. Areas of Focus
   (1) Priority approach

In the S&T of the energy field, R&D must be prioritized according to the long-term outlook and the following perspectives.

(a) Diversification of energy sources to match the future society and economy

Japan is heavily dependant on overseas energy sources, and must diversify sources to ensure stable supplies. In this sense, in primary energy, we must promote effective use of fossil fuels such as oil, natural gas and coal, while putting an emphasis on R&D for expanding the use of non-fossil energy including renewable energy and nuclear power. Active R&D is also needed for the use of hydrogen as a secondary energy source, which would contribute to the diversification of primary energy sources. However, in conducting R&D on these themes we must go beyond merely increasing energy options, and focus on developing energy sources that will match the social and economic needs of the future. These sources must be fully accepted by the public in terms of economic efficiency, environmentally clean properties, safety, and supply stability.

(b) Energy systems with lower carbon emissions

Global warming has become one of the most pressing issues for the world. By 2010, Japan must reduce greenhouse gas emissions by 6% from the 1990 figure, and will have to face more severe goals further after. Since approx. 80% of greenhouse gas is energy-derived CO_2, S&T must be explored to prepare new options to solve the issue. In addition to (a) Diversification of energy sources to match the future of society and the economy and (c) Enhancement of the efficiency of energy systems , we must conduct R&D on energy conservation, alternative energies, and the decarbonization of energy systems such as energy-saving renewable energy and nuclear power. This factor is also important in the environment field, and should be explored as one of the focal tasks.

(c) Enhancement of the efficiency of energy systems

Japan has so far developed and introduced various technologies for energy conservation, and is internationally acknowledged for its advanced efforts in this respect. For the future, it is necessary to improve the efficiency of energy systems as a whole. We must promote R&D for revolutionizing and advancing energy systems as a whole, R&D for improving the infrastructures of energy systems, and R&D on alternative energy systems in consideration of changes in social needs.

(d) Improvement in fundamental S&T

The energy field represents the accumulation of a broad range of S&T. Consolidating this foundation is essential in achieving breakthroughs, creating innovative technological options, and applying them to society. R&D is particularly needed on energies that support the overall industrial and economic activity, not only in respect of themes that are expected to materialize in the short to medium term, but of themes that represent long-term investments for the future. In order for energy systems to be accepted by society and the public, we must undertake human and social science studies, such as research on the impact of energy on society and people, and evaluation of energy-related R&D and policies.

(2) Priority tasks

R&D in the S&T of the energy field includes the development of technologies for diversifying energy sources, promoting energy conservation and advanced energy use, and utilizing nuclear power. These technologies are important, and must continue to be promoted in R&D both efficiently and steadyly.

In order to promote these conventional R&D themes efficiently and steadily, the following themes will be defined as focal areas of the energy field for the next five years, based on the priority perspectives (a) to (d) mentioned above. Specific tasks for each theme are as set out in "3. R&D Targets in Focal Areas".

(a) R&D for transforming the overall energy system, encompassing supplies, transport, conversion and consumption

Focus on the "energy system" aspect as a fundamental and efficient approach toward achieving the 3Es.

(b) R&D for enhancing energy-related infrastructures

Focus on various factors associated with energy infrastructures that support the overall energy system, with a view to enhancing the aspects of efficiency, environment, etc.

(c) R&D for energy safety and security

Conduct R&D for ensuring safety and security to the public in respect of all aspects of the energy field.

(d) R&D for assessing and analyzing energy system, both socially and economically

Since energy systems are closely associated with various aspects of society, economy and the environment, focus on making a comprehensive analysis and assessment of such factors, on enhancing social awareness and acceptance of the energy system, and on exploring energy systems from the industry-creation point of view. The outcome of R&D themes in (d) should be reflected in the R&D of (a) to (c) mentioned above.

3. R&D Targets in Focal Areas

The following are the R&D targets in focal areas, to be achieved within the next five years.

(1) R&D for transforming the overall energy system encompassing supplies, transport, conversion and consumption

(a) R&D of new energy systems with a focus on supplies

i. Hydrogen energy system

Develop technologies for manufacturing, transporting, storing and utilizing hydrogen for the preparation of broader application of hydrogen-based fuel cells in 5 years' time,. Also, verify the viability of hydrogen stations and improve system infrastructures (standardization, etc.) for using hydrogen energy.

ii. Technology for developing and utilizing biomass energy

Improve the conversion efficiency of unutilized biomass energy into a more versatile fuel format, while developing technologies for reducing costs, conducting tests on system technologies, and launching model projects.

iii. Technology for manufacturing and utilizing DME (dimethyl ether) and GTL (gas to liquid) (liquid fuel from natural gas etc.)

Develop efficient and low-cost production technologies, conduct verification tests to establish utilization technologies, and develop security regulations and specifications, with the aim of launching commercial production within 5 years.

iv. Nuclear fuel cycle

In the use of nuclear power as an energy source, it is essential to establish nuclear fuel cycle system for enhanced use of the resources. Steady R&D should continue from the mid- to long-term perspective in the areas of uranium enrichment, nuclear fuel re-processing, MOX fuel processing and fast-breeder reactors (FBR). Five-year targets include defining the final specifications for the new centrifugal separator for use in uranium enrichment, and narrowing down candidate concepts for the practical application of the nuclear fuel cycle in FBR introduction.

v. Long-term R&D themes

Seek to establish foundation technologies for areas that need systematic and steady development efforts and gradual technological verification before practical application. Examples of these include nuclear fusion power generation, space solar power, ocean energy utilization, and methane hydrate development (ice-like solid matter comprising methane and water molecules), so that they will offer added energy supply options in the future.

(b) R&D of new energy systems with a focus on transport and conversion

Regarding the use of superconductivity in electric power, seek to establish component technologies for use in highly-efficient power storage units, power generators, cables, transformers, etc., with the goal of system introduction in around 10 years.

(c) R&D of new energy systems with a focus on consumption

Regarding urban energy systems including EMS (Energy Management System) with advanced IT infrastructures, and other systems for houses, buildings and transport, seek to develop optimum control technologies, evaluation methods and energy conservation systems in the next five years.

(2) R&D for enhancing energy-related infrastructures

(a) Improving the efficiency of energy-related devices, etc.

i. Fuel cells

Conduct foundation research into fuel cells, from small types to large capacity types for power generation, alongside efforts to develop a prototype for automobile use with a view to reducing costs.

(Reference)

In the development of the Polymer Electrolyte Fuel Cell, aim at developing an automobile fuel cell of approx. 5,000 yen/kW, and a fixed fuel cell system of around 300,000 yen per unit (for household use).

ii. Solar power

Disseminate the use of solar panel units, and at the same time conduct foundation research into materials so as to reduce costs through improving conversion efficiency.

(Reference)

Aim to develop solar power units with power generation cost of 30 yen/kWh and unit installation cost of 370,000 yen/kW. Reduce these costs to 25 yen/kWh and 300,000 yen/kW respectively in 10 years, and 10 to 15 yen/kWh and 200,000 yen/kW respectively in 20 years.

iii. Oil exploration and usage technology

Develop the technology for remote exploration of oil resources, and achieve advanced technology in oil refinement and usage.

iv. Clean coal technology (clean use of coal)

Conduct the IGCC (Integrated Coal Gasification Combined Cycle) verification test, and improve thermal efficiency.

(Reference)

Establish a combustion system, etc., for improving the thermal efficiency (net) from the current 39% to 46 - 48%, and develop foundation technologies to further enhance the efficiency to around 55%.

v. Cogeneration technology

Work toward developing advanced technologies to lower costs and improve efficiency of power generation.

vi. Development of clean energy automobiles

Regarding the technologies for zero-emission, clean energy automobiles, develop component technologies for improving engine performance and efficiency of energy regenerative devices.

(b) Developing various materials for energy devices and infrastructures

Conduct foundation research into new materials such as ultra low-loss power devices, superconducting materials, highly efficient photoelectric conversion devices, heat-resistant single crystal superalloys and reliable, highly thermo-tolerant ceramics, for their practical application to energy devices and infrastructures.

(c) Innovative technologies

Seek to establish the technological foundation of innovative tasks, such as innovative nuclear reactors and bio processes (production process utilizing biotics), with a focus on incineration of actinides, reduced geographical constraints and diversified use.

(3) R&D for energy safety

(a) Disposal of radioactive waste

Conduct research into the geological environment in relation to the disposal of radioactive waste, and develop data, models, etc., for design and safety assessment.

(b) Technology for improving nuclear power safety

Pursue advanced technologies to guarantee safety through verification tests..

(c) Technology for enhancing safety regarding energy supplies and usage (e.g., electricity and gas)

Develop individual technologies for risk assessment, life span projection, etc.

(d) Safety assessment research for natural gas pipelines

Establish safety assessment for long-distance undersea pipelines, etc.

(4) R&D for assessing and analyzing energy socially and economically

(a) Research concerning the general analysis and assessment of energy systems, covering the economic and environmental aspects

Develop methods for an environmental impact assessment of various energy systems, through comprehensively analyzing and assessing the impact of energy systems on society, the economy and the environment, and by conducting life-cycle assessment (from resource extraction to waste disposal).

(b) Research on the social understanding of nuclear energy use

Analyze and assess impediment factors unique to nuclear power, and devise measures for improving its social acceptance.

(c) Research into incentives for promoting energy conservation

Under the initiative of the private-field transport industry, conduct a study into the reality of energy consumption in each social system (by city, structure or transport), use the findings to research measures for promoting energy conservation, and develop analysis and assessment methods for monitoring human behavior in energy consumption.

(d) Research into incentives for introducing alternative energies

Seek to compile proposals (policy options, etc.) for achieving the goal of introducing and disseminating alternative energies.

4. Basic Issues for Promoting R&D

(1) Issues for improving the quality and efficiency of R&D

(a) International cooperation

International energy-related problems could pose serious threat to Japan's national security. Japan must work toward producing internationally transferable R&D results, and actively transfer them chiefly to developing countries.

In addition, large-scale advanced R&D should be conducted not only within Japan but also in partnership with other countries. Participation in international R&D is significant for Japan from the perspectives of international contribution and the efficient and effective implementation of R&D.

(b) Dissemination of R&D results and R&D assessment

Social and public understanding is essential when introducing and disseminating the results of R&D on large-scale energy systems. Study into social understanding should be incorporated into the process from the R&D stage.

In introducing and disseminating fuel cells, biomass energy, etc., it is necessary to address unsolved issues regarding their energy supply sources and material procurement. Therefore R&D programs should be designed with the prospect of future application and popularization fully incorporating social, policy and system aspects

In addition rigorous review on R&D programs is essential for efficient and effective operation.

(c) Trilateral partnership and role sharing

R&D of energy systems represents an aggregation of associated technologies. This makes it extremely inefficient and unproductive for a single entity to handle all aspects of R&D. The industry should take the initiative in themes having a strong association with market principles, while universities and research institutes should cover foundation themes for discovering basic principles, etc., so that the overall progress takes place in mutual cooperation. Based on this approach, R&D should be promoted under an effective partnership and role distribution among industry, academia and government.

(d) Efficient R&D promotion, with coordination among government bodies

Technological development for alternative energies and energy conservation must be handled across ministry and agency borders, encompassing the introduction and dissemination stages. To achieve an efficient approach, it is important to ensure coordination among government offices.

(e) Combination of short-, medium- and long-term R&D themes

In order to develop a technological system that is desirable from the perspective of the 3Es, it is necessary to combine short-term goals (cost reduction, efficiency inprovement) with medium-term goals (practical application of innovative technologies) and long-term goals (foundation S&T, in a bid to take a consistent approach). Long-term goals should be assessed according to long-term plans, and reviewed as required for steady continuity.

(2) Resource issues affecting R&D

(a) Ensuring and fostering human resources

With increasing concerns in recent years over human resource supplies, especially in the nuclear power field, a social issue is arising over whether young people find careers in this field attractive. In view of the importance of long-term R&D themes, we must secure and foster human resources to maintain the field's technological foundation and promote further R&D. To this end, students should be further enlightened on the importance of energy issues, particularly issues surrounding effective use and safety of energy, not only in tertiary and higher education but also at elementary and secondary schools.

Manufacturing Technology

1. Current Status of the Manufacturing Technology Sector
   (1) Current status
      (a) Manufacturing technology continues to be Japan's lifeline and source of economic strength in the 21st century.
         - Although the industrial structure becomes more service-oriented, and despite the progress of the IT revolution, the manufacturing sector continues to claim a significant position in the Japanese economy, serving, undoubtedly, as the core industry of the trading nation.
           The manufacturing sector accounts for 25% of all Japanese industries in nominal GDP and workforce representation.
           The manufacturing sector represents 70% of all imports / exports, earning foreign currency well over the trade deficit incurred by other industry sectors.
           The manufacturing sector makes up approx. 50% of all interim GDP injections, providing products that support a broad range of economic activities.
         - We must acknowledge that strengthening this sector's international competitiveness is essential in order to ensure the sustainable development of the Japanese economy into the 21st century. Efforts should be made to induce innovation in manufacturing technology.
         - Enhancing this sector's international competitiveness is also important from the perspective of providing good quality employment.

      (b) There is a downward trend in Japan's technological competitiveness and its basic research's industrial contribution.
         - In order to maintain the sector internationally competitive, we must clearly define R&D themes in manufacturing technology, and make qualitative and quantitative improvement in basic research at universities, etc., where innovation originates.
           The U.S. evaluation puts the United States ahead of Japan in the comparison of technological competitiveness between the two countries (1999 council for industrial competitiveness).
           Science linkage (number of science thesis quotes per patent application) in manufacturing technology has dropped sharply since 1995, widening the gap with the United States, which used to be at the same level as Japan in this regard.

      (c) Attention must be also paid to the environment surrounding manufacturing technology, in addition to science and technology themselves.
         - The debates on the strategy of promoting "manufacturing technology", must cover not only scientific / technological contents but also peripheral factors that affect manufacturing technology.
           Relationship with social systems, laws / regulations, and industrial policies
           National security management (energy, food security, etc.)
           Corporate activities (business models, globalization, market demand, employment issue, etc.)
           High-cost structure (energy, logistics, taxation, infrastructures, labor)
           Perspective of international contribution (globalization and offshore labor, etc.)

In regard to these surrounding factors, it is important to examine issues that impede efforts to develop / proliferate the results of R&D on manufacturing technology, and draw up proposals for countermeasures.

(2) National / social demand and themes of technological innovation in this sector

(a) Enhanced industrial competitiveness and sustainable socio-economic development

Japan, with its trade-oriented economy, must ensure its manufacturing sector remains internationally competitive so as to achieve sustainable economic development into the 21st century. It is important to bring further innovation to process technologies for high productivity, which Japan has been reputed for, and cause new industrial transformation through integration with the IT revolution. (Further promotion of process innovation)

It is also necessary, at whatever cost, to constantly produce new products of high added value to withstand international competition, as well as new manufacturing technology required to produce such products. (Enhanced product innovation)

To link superior technology to the final goal of enhanced corporate competitiveness, we must strengthen our comprehensive capacity encompassing management strategy, efficiently and swiftly summoning individual technologies to put new products into the market. (Integration with business model innovation)

The manufacturing sector is undergoing structural transformation as a result of globalization, driven by the high-cost industrial structure within Japan. The urgent task now is to bring about fresh international competitiveness to consolidate the foundation of this trade-oriented nation.

(b) Harmony with the global environment and advanced energy use

The 21st century will demand that the manufacturing sector resolve resource / energy constraints to overcome environmental issues, so that we can conduct healthy economic activities and contribute to the development of a comfortable society. The sector must address these issues and assume the key role in a recycling-based society as a way of achieving sustainable economic growth.

Manufacturing technology is closely associated with the effort to seek harmony with the global environment. It is necessary to promote production systems that conform to a recycling-based society, technology for minimizing the risk of hazardous chemicals, and technology to control global warming.

Since Japan has a fragile structure in the supply / demand of energy, constant progress must be achieved in technologies for energy conservation and advanced energy use. For the time being, the priority should be given to the goal in reducing greenhouse gas emission by 2010, as set out in the Kyoto Protocol adopted in the Third Conference of the Parties to the UN Framework Convention on Climate Change.

(c) High quality of living in a graying society

In the accelerating trend of population aging with a low childbearing rate, Japan needs to create manufacturing technology with an emphasis on the elderly needs in terms of working environment and products.

In the area of working environment, we must inherit elderly people's technologies and skills associated with manufacturing technology, while developing the environment that senior-aged workers can handle safely and securely.

In the area of products, foundation technologies for medical / elderly care equipment must be strengthened to meet the demand of a graying society. Despite having basic technologies for this area, Japan has failed to exert its full competitive potential until now. Countermeasures need to be explored to promote R&D and improve peripheral factors in the welfare system.

2. Areas of Focus

(1) Priority approach

The following perspectives are used to clearly define areas of focus to be promoted, taking the "selection and concentration" approach to adequately address national and social demands on manufacturing technology.

(a) Enhancing competitiveness through innovation

Areas for strengthening international competitiveness of the manufacturing sector, now undergoing structural change in the wake of globalization, so as to lay the foundation for bolstering economic growth.

(b) Pioneering new areas of manufacturing technology

Areas of manufacturing technology, expected to have mid- to long-term demand

(c) Minimizing environmental strain

Basic areas that form the foundation for future development in manufacturing technology

(2) Defining areas of focus

(a) Enhancing competitiveness through innovation

i. Productivity breakthrough with advance IT use

Productivity breakthrough can be expected in diverse areas through integrating manufacturing technology with information technology, currently experiencing rapid advancement described as the IT Revolution.

(i) Technologies for productivity enhancement, effectively utilizing know-how on manufacturing floors, technologies that have not been systemized, and digital data compilation of past failures / experiences.

(ii) Technologies for productivity breakthroughs through advancement of computer-oriented manufacturing technology such as CAD, CAM and CAE.

ii. Technological breakthrough for process innovation

Manufacturing technology involves specific manufacturing processes for individual industry areas such as machinery, electricity, metal, food and chemicals. Persistent efforts to improve their efficiency have brought them to today's standards. Each of the processes has the technological basis for opting for the present format. Using a fresh approach to cause a technological breakthrough to the existing basis, is essential to develop innovative manufacturing processes with outstanding efficiency and low costs, thus enhancing industrial competitiveness.

Many attempts for such innovative process development have been traditionally conducted as national projects, due to the significant risk associated. Yet, careful choice of themes and advance assessment should be made, in reflection of cases whereby the discrepancy in feasibility study findings before and after R&D led to the cancellation of practical application.

iii. Advanced technologies for quality control, safety and maintenance

Debate has been broadly conducted, even at the national level (Consultation Group on Manufacturing), on the comprehensive and systematic promotion of foundation technologies for manufacturing, which have bolstered Japan's manufacturing sector, out of concerns over the nation's manufacturing capacity including quality control, etc. As seen in the Consultation Group's report, countermeasures must go beyond science / technology issues to encompass a wide range of factors such as human resource development, business models, traditional skill conservation, and deregulation. Bearing such peripheral factors in mind, we must clearly define what aspects should be pursued in R&D.

(b) Pioneering new areas of manufacturing technology

i. Technology for developing products of high added value

While raising the efficiency and productivity of existing manufacturing technology, we must also give fresh or more advanced added values to individual products so as to pioneer new areas of manufacturing technology. Japan has traditionally shown strength in the manufacturing of high-feature components and materials. Cutting-edge technologies for micronization (micromachines, applied manufacturing nano-technology, etc.) and advanced high-features (intelligent robotics, optoelectronics, bio-optoelectronics, etc.), among others, need to be explored to create new added values.

ii. Technology for cultivating new demand

There are various technologies that may create new demand. For example, in the graying society with a falling childbearing rate, the need for facilitating the elderly's safe and secure social activities, triggers new demand in a broad range of areas associated with human living. Expectations are particularly high for medical / elderly care equipment, making it necessary to enhance foundation technology for this area.

There is also a need to make basic know-how in manufacturing technology available for sharing, and develop the European / U.S. level technological metayard. As part of this effort to improve intellectual infrastructures, the area of high-precision evaluation machinery, etc. must be strengthened.

(c) Minimizing environmental strain

i. Production system for shaping the recycling-based society

There is a need for technology that materializes recycling-based society, promoting effective use of resources, containing waste generation, and seeking resource recycling through the introduction of production systems designed for minimizing resource injection and waste. To this end, we must develop the 3Rs (Reduce, Reuse and Recycle) technologies and adopt an approach for combining them.

The implementation must be promoted according to clearly defined policies, such as taking a comprehensive approach with specific products of a large market size, or conducting R&D on component technologies shared among a wide range of products.

ii. Technology for minimizing hazardous materials

The nation needs technologies for minimizing, assessing and controlling the risk of chemical substances hazardous to human health and ecosystems. R&D themes required include developing ways of minimizing hazardous substances generated from manufacturing processes and manufactured goods themselves (dioxin, ozone depleting substances, etc.) and reducing the risk of such chemicals.

The areas of applied nano-technology, etc. should be encompassed, as this category requires technologies for sensing, reducing or removing minute amounts of chemicals.

iii. Technology for global warming

Technology is urgently needed to counter global warming, including minimizing and collecting greenhouse gas emission. Japan is making concerted efforts to achieve the goal set out in the Kyoto Protocol, adopted in the Third Conference of the Parties to the UN Framework Convention on Climate Change. The manufacturing technology sector needs active pursuit of technologies for resolving difficult energy conservation issues (producing energy at high efficiency, effectively utilizing unused energy, recovering low-medium temperature heat exhaust, etc.). In addition, efforts should be made to explore solar power cells, H2 storage technology, fuel cells, wind power generation, etc.

3. R&D Targets in Focal Areas

(1) Enhancing competitiveness through innovation		
Focal area	Achievement target	Specific themes
(1)-A Productivity breakthrough with advanced IT use	Make advanced use of IT to enhance competitiveness of this sector amidst the trend toward globalization	Digitizing / systemizing skills (know-how) Practically applying technologies of advanced digital engineering, such as CAD
(1)-B Technological breakthrough for process innovation	Make a technological breakthrough to achieve unique manufacturing processes with international competitiveness	Establishing the seedlings of innovation, such as applied nano-technology, new catalysts, micro-modulation of chemical processes and combinatorial technology
(1)-C Advanced technologies for quality control, safety and maintenance	Ensure Japan's continued superiority in technologies for quality advancement and safety	Achieving production systems with self-control / self-diagnosis functions, and developing un-manned inspection processes through quantification of evaluation based on human senses
(2) Pioneering new areas of manufacturing technology		
(2)-A Technology for developing products of high added value	Pioneer products of high added value that only Japan is capable of developing, through micronization and composite advanced features	Examining the applied potential of micromachines and microfactories, and establishing the foundation for nano-manufacturing technology Establishing the foundation for composite functions, combining bio / optical functions and electronics

(2)-B Technology for cultivating new demand	Establish the foundation of manufacturing technology for medical / elderly care equipment, life science, etc. for advanced social welfare, and prepare associated intellectual infrastructures	Establishing the foundation technology associated with the manufacturing of medical / elderly care equipment, regenerative medicine, and foods with health benefits Developing a database for the practical application of high-precision evaluation equipment and the development of associated materials
(3) Minimizing environmental strain		
(3)-A Production system for shaping the recycling-based society	Make a practical application of 3R technology (Reduce, Reuse and Recycle) for achieving the waste reduction target	Establishing the foundation for applying recycling-based production systems, emission-free manufacturing technologies, and recycling waste / by-products, and establishing the foundation for the LCA system
	Develop social infrastructures for embracing recycle-oriented society	Practically applying the systems for assessing fatigue / corrosion Searching for optimum cross-industrial infrastructures through simulation, and identifying associated tasks
(3)-B Technology for minimizing hazardous materials	Make a practical application of technologies for lowering hazardous materials generated from manufacturing processes / product themselves, and minimizing the risk of chemical substances	Practically applying the technologies for using components and manufacturing processes free of substances straining the environment Establishing the technologies for analyzing hazardous substances in minute quantities
(3)-C Technology for global warming	Establish and make practical application of comprehensive technologies for energy conservation and alternative energy, so as to achieve the target defined in the Kyoto Protocol (COP3)	Establishing and practically applying energy conservation technologies (e.g., collecting low-temperature heat exhaust and using energy cascade) and alternative energy technologies (e.g., solar power cells,, fuel cells and hydrogen energy)

R&D to be conducted under national initiative

In the manufacturing technology sector, it is the industrial circle that puts R&D outcomes into practice. In order to maintain their competitiveness and advantage, in many cases the industrial circle conducts R&D themselves. In the given situation, there is a need to clearly define R&D themes that should be conducted under government initiative. These include:

- Pioneering cutting-edge technologies with international competitiveness
- Promoting basic and comprehensive research for supporting cutting-edge technologies
- Conducting basic research for developing production technologies / products that help maintain Japan's industrial superiority
- Developing the intellectual foundation associated with manufacturing technology (thus developing infrastructures, etc. required for promoting this)

4. Basic Issues for Promoting R&D

The following measures must be taken alongside R&D in order to utilize technological innovation for enhancing industrial competitiveness:

(1) Preparing the environment for fostering human resources and facilitating their creativity

Foster human resources capable of understanding the underlining elements of social needs and manufacturing technology, and reforming processes / products with an innovative approach.

Develop advanced manufacturing engineers through enhancing training institutes, organizing adult education, and swiftly responding to cutting-edge technologies

Make effective use of overseas human resources

Improve the environment, e.g. R&D facilities, budget system and education system, for fostering a creative workforce.

Improve the environment for promoting the integration of priority manufacturing technology with cutting-edge technologies, including IT, nano-technology, life science and environmental studies.

(2) Developing the knowledge foundation, technologies and know-how

Accumulate technologies and know-how for the innovation of process technology, foster human resources capable of supporting the target, and scientifically analyze / systemize the know-how / skills that have been so far left unorganized on manufacturing floors.

Scientifically analyze past failures and accumulate the knowledge, so as to develop the environment for utilizing such information for future work. (Database for utilizing failure information)

(3) Strategy on intellectual property rights

Incentives on acquiring intellectual property rights

Subsidizing the cost of patent acquisition

A system should be introduced to subsidize in full or in part the costs of acquiring patents as a result of R&D under the government's research assistance program, providing added incentives to researchers, universities, TLO, etc.

System for encouraging discoveries and associated technologies, significant in corporate strategies, to be registered for IPR comprehensively and internationally

Support for starting business with patents subject to the above incentive

Develop support measures, such as the government partially underwriting liability guarantee, for ventures to be started using patents acquired in the above system.

An implementation body should be set up to enable a speedy response to TLO and private-sector companies.

Define set standards in the scale of ventures (within X years of establishment, capital of under XXXX yen) in providing assistance.

Society and system that provides due credit to inventors

Failure to give due credit to inventors would impede future discoveries and patents. Support should be provided to ensure IPR of innovative inventions by researchers at public organizations, national universities, etc., while it should also be promoted to develop a system for providing adequate rewards. Social values should also be adjusted so as not to discourage researchers from starting business.

(4) Tri-sector partnership

- It is important to forge partnerships and distribute roles between the industry sector and the academic / bureaucratic sectors from the initial stage of research. R&D needs and themes must be shared in the case of the manufacturing technology sector in particular. Measure should be taken to make the partnership obligatory at the time of selecting R&D themes.
- Fostering human resources (talent, scale) in the "academic / bureaucratic" sectors is an important task, so as to accept R&D themes commissioned based on "industry" needs. For this reason, human resources should be flexibly moved from the private to academic / bureaucratic sectors to swiftly foster research personnel and swiftly respond to R&D themes.
- At the same time, as a way of fluidizing human resources to apply the results of university research to industrial use, the Industrial Technology Enhancement Law, enacted in April 2000 has enabled instructors at national universities to take up corporate directorship concurrently under certain conditions. It is necessary to further utilize the law and introduce measures to ease the adverse impact of this system.
- The industrial, academic and bureaucratic sectors must work in organic coordination or in the matching fund systems, so as to make the maximum use of research resources (human resources, research fund, research facilities, etc. held by the three sectors) and link them to technological innovation on manufacturing.
- In tri-sector partnerships, there should be a prior agreement on the IPR of research achievements by the "academic / bureaucratic" sectors. Also, full considerations should be given to the issue of conflict of interest.
- Past examples show that it is the university side that proposes innovative seedlings that may lead to major breakthrough in manufacturing technology. Universities are expected to initiate a major tide of technological innovations.
- Taking advantage of the tri-sector partnership, it is also expected to take on big projects that are difficult for any single sector to handle, so as to broaden the horizon of manufacturing technology.

(5) Developing the intellectual foundation and promoting standardization

- Promoting database development in mensuration, measuring technology, etc.
- Developing measuring / analysis technologies for handling microscopic / high-precision casting / processing
- Preparing basic data on the safety of medical / elderly care equipment, and on material designs (reference materials, equilibrium diagrams, basic physical properties, catalyst functions, etc.)
- Promoting basic research into safety, and establishing organizations for researching the

safety of the entire product lifecycle, including manufacturing processes

- Promoting the standardization of systems and components for the technologies for new casting processing or measuring analysis. (micro fluid / chip system, micro-valve, micro heat exchanger, etc.)

(6) Measures for encouraging venture businesses

- In new areas of manufacturing technology, the venture business format is the more effective way of entering the market. Support measures should be introduced to facilitate the move. Introduction of support measures should also be considered for companies branching out to new areas.

  Such measures should take the perspective of ensuring that the venture is based on advanced technology that forms the foundation of manufacturing technology in the future, that a large number of employment opportunities are to be generated, and that the venture is in coordination with universities for logical substantiation.

  Emphasis should be placed on measures for facilitating patent acquisition both in Japan and overseas, allowing ventures to identify multiple options for each of the market needs, and extending financial help toward the provision of infrastructure facilities.
- Active utilization and application of TLO needs to continue, so as to ensure a smooth transition of university research outcomes to the business sector. It is particularly important to actively utilize TLO for matching new technologies with business needs. The introduction of a consortium-style TLO, etc., should also be considered.
- The 1995 Small and Medium Business Support Activities Law, etc., stipulates support measures for small / medium business operators. Efforts should be made to encourage active use of such grant systems.
- The Small Business Innovation Research system (SBIR) should be utilized as a way of providing consistent support for small / medium enterprises from the stage of technological development to business application.

(7) Tasks in management, business models and science / technology policies

- Promoting transition into new business models and easing associated regulations
- Establishing a business model for taking maximum advantage of new manufacturing technology
- Examining science / technology policies to utilize innovation to effectively achieve economic growth

Social Infrastructure Sector

1. Current Status of the Social Infrastructure Sector

(1) Civilization and Social Infrastructures

Applying the Western model of social infrastructures, Japan has undergone modernization with a focus on R&D and construction since the Meiji Era. Yet, people continue to suffer damage from disasters and accidents in an increasing gravity, as our society becomes more advanced and the cities greater and more congested.

Most Japanese cities have emerged and expanded around political centers, with a notable absence of the "communal" concept shared among European cities. For this reason, cities have continued to disorderly erode pastoral lands. Social infrastructures have been developed to address problems as ad hoc and stopgap measures without following any ideals. Consequently, our cities and their surrounding communities are left in an extremely poor state. Their chaotic state is not just unaesthetic but also lacks the systematic foundation for supporting efficient economic and social activities.

The core problem of Japan's social infrastructures lies in the clear absence of policies for systematically and comprehensively developing social infrastructures, awareness in the R&D of science and technology areas, and associated investments. Unless these situations are improved, promoting science and technology would not lead to revitalizing our economy, enhancing our international competitiveness, or achieving the Quality of Life (QOL) suitable for a matured society in the 21st century.

In this sense, we must promote systematic and comprehensive R&D activities under the visions of building a safe and secure society, and developing a beautiful environment that supports a high QOL.

R&D in the social infrastructure sector has significance from international perspectives, in addition to the need for restoring our national land. Many emerging economies more or less, appear to be making the same mistakes.

The technologies, methods and concepts, based on Japan's experience and designed for restoring cities and national lands, will be broadly applicable in the development of social infrastructures in emerging economies, rather than those of any developed countries.

Japan is suitably positioned to resolve many difficult issues the world currently faces in this sector, and take the initiative in extending technological cooperation to developing countries, which find themselves in a more-or-less similar situation, from the perspective of contributing to sustainable development.

(2) Trend in the Social Infrastructure Sector

Japan boasts the world's highest level of technologies in constructing major facilities (tunnels, bridges, dams, etc.), improving the ground conditions, utilizing coastal / offshore areas, using underground space, and developing transportation (high-speed railway services, etc.). Combined with our traditional technologies, Japan explores a diverse range of technologies and systems to develop, maintain and manage social infrastructures.

The first major technological revolution after the World War II stems from the proliferation of computers and improvements in quality control. The development of analysis methods on non-linear structures has brought significant changes in the way social infrastructures are designed, and subsequently led to establishing the construction methods for materializing them. Various technological standards, which support today's science / technology systems, were devised to systematically promote land / social infrastructure development according to the needs of the time, and in line with a series of government programs for reorganizing and comprehensively developing the nation including "The plan to remodel the Japanese archipelago."

The next major change came in the early 1990s. Following the Structural Impediments Initiative talks with the United States, Japan found its structure of infrastructure development under the influence of internationalization, and began inclining toward infrastructure policies for achieving the status as a "Lifestyle Superpower". The 1992 Earth Summit in Rio de Janeiro (U.N. Conference on Environment and Development) put Japan under a strong influence of the concept "Sustainable Development". Against the backdrop, the nation saw the emergence and development of new science / technology sectors, such as landscape designs techniques and environmental studies.

In the mean time, risk management measures were introduced as part of the social infrastructure policies. The 1995 Great Hanshin - Awaji Earthquakes (Kobe Earthquake) highlighted their necessity, prompting risk management R&D on new infrastructures that address our high-density socio-economic systems and urban activities. R&D was also conducted on technologies for reducing costs and reducing environmental strain, as well as methodology for encouraging public participation. R&D focus has since broadened to develop infrastructures with "lifecycle costs" in mind, and conduct R&D into technologies for regenerating and restoring the environment.

Now is the time of a new revolution.

Firstly, IT Revolution is transforming the way social infrastructures are developed and managed. The development of information technology is making it increasingly likely to build an advanced control system for national lands and social infrastructures, with R&D efforts already underway.

The tide of economic globalization is dealing a significant impact on the way social infrastructures are. Take transport systems for example. Japan is suffering a relative deterioration in international competitiveness, and is conducting R&D for regaining the competitive edge.

Turning your eyes to the world, you see clashes of various different sets of values, and clear confrontation on the issue of globalization vs. regionalization often triggering major social and international disputes.

Development assistance from the public sector of developed nations is not sufficient to help developing countries achieve sustainable development. The entire world is seeking ways of developing a new system for maintaining and controlling infrastructures of developing countries.

In addition, the lack of social systems that brace for natural disasters is now under the spotlight following the collapse of the reinsurance system, which has served to finance disaster redress.

In the future, the trend of such serious global issues should be observed in proceeding with R&D of the infrastructure sector.

(3) Tasks of technological innovation in the social infrastructure sector

① Society and infrastructure science / technology

Technological innovation of the social infrastructure sector is only meaningful when the technologies are applied in the administration and accepted by society. R&D could prove to be meaningless if it is too detached from social ideals and values.

The social infrastructure sector must now depart from the approach following the modern Western countries, and create a science / technology system to adopt a new approach, which is based on our unique cultures / values / lifestyles, offers international characteristics, is suitable for a matured society of the 21st century, and substantiated by the ideal of restoring our beautiful national lands. Until now, there was no methodology and strategy for organically combining individual technologies based on such ideals, and perfecting them as a comprehensive system. This has been the cause of the substandard environment brought onto Japanese cities today.

Needless to say, this methodology and strategy must deliver unity and organic consistency throughout all phases from planning to designing, construction, maintenance, management and administration, and between individual social infrastructures. It is difficult to communicate among different type of specialties, administrative organs, and businesses.

In addition, no systematic and continuous R&D efforts are implemented for important R&D tasks that fall upon border areas of different budget systems and administrative organizations (e.g., areas of public works, welfare and international cooperation). There is also an insufficient level of efforts to enhance the inter-prefectural research (border area of national and regional governments) and support regional administration, so as to help local governments fully exercise their diverse characters and creativity for mutual competition.

In this sense, policy considerations should be made to provide incentives for combining the science / technology system and development methodology, and encouraging various proposals.

In order to have society accept R&D results based on the new science / technology system, we must also explore ways of participation and cooperation by local residents / organizations, NPO, etc., methods for economically and socially evaluating social infrastructures, and legal studies on the relationship between private rights (e.g., property ownership) and public interest.

In a related matter, cadastral studies have shown little progress despite the fact that they provide a basis for issues surrounding land ownership. GNSS (Global Navigation Satellite System) and other new technologies should be incorporated into the studies for actively promoting R&D.

② Administration issues on infrastructure science / technology

All in all, R&D of infrastructure science / technology has an extremely insufficient level of advanced information foundation using IT and other cutting-edge science / technology, especially in the administration sector.

For example, central and regional government offices are developing database for GIS (Geographic Information System), etc., but have failed to fully integrate the systems mutually. Efforts must be made to utilize various data organically and systematically.

Especially in regard to infrastructure development associated with natural environment, disputes and social confrontations have often continued endlessly without concerned parties sharing accurate data. It is desirable to develop a system for building, publicizing and sharing databases.

In projects of social infrastructure development, central and regional governments tend to settle for specifications based on already established technologies. However, incentives should be given by revising technological standards without hesitation so that they are encouraged to actively adopt various new technologies on a trial basis, and revise if such attempts lead to the emergence of excellent technologies.

2. Areas of Focus

(1) Prioritization approach based on tasks of the social infrastructure sector

In R&D of the social infrastructure sector, priority should be given to areas that are fundamental to our nation's existence and must be conducted under the national initiative. According to this approach, and based on the current status of this sector (described previously), R&D prioritization strategy should take the perspectives of (1) ensuring safety, (2) restoring the national lands and improving QOL, and (3) achieving international cooperation.

① Ensuring safety

Protecting citizens' lives and properties from disasters and accidents is the minimum required obligation fulfilled by the central government. Minimizing damage has an immeasurable economic effect.

Massive financial resources have been injected into this area. Yet, we have so far taken the modern Western concept of confronting and controlling Nature. It remains to be seen whether the approach is suitable for the characteristics of Japan's natural conditions.

Japan lies in the Asian Monsoon area, and belongs to the zone of frequent earthquakes and volcanic eruptions. It has the fate of living a high-density living on a vulnerable alluvial plain. Under these conditions, it is more appropriate to seek coexistence with nature rather than controlling it.

More specifically, we should counter damage from unusual natural phenomena with the approach of mitigation (minimizing damage regardless of the scale of natural force) instead of eliminating damage (ensuring no damage for a certain level of natural force). Based on this ideal, we must further enhance R&D of technologies / systems incorporating the risk management concept on all phases of social infrastructures, from planning to designing, production/ construction, management and administration.

In contrast, all-out efforts must be made to prevent and control disasters stemming from accidents and human-related causes. At the same time, in preparation for unfortunate cases of such disasters occurring, it is appropriate to conduct R&D with a focus on mitigation.

Incidents and crimes that were once inconceivable, are now stirring up anxiety across society. Comprehensive R&D is needed with emphasis on the importance of human factors in social infrastructures.

The central government must make sincere efforts to establish a science / technology system to this end, and implement measures that apply the new system.

② Restoring national lands and improving QOL

In the 21st century, all Japanese people should be able to express their individuality and live fulfilling lives, supported by the aesthetic and functional social infrastructures as well as the minimum requirement of safety. While accommodating diverse values for all individuals, the entire society must become equipped with the infrastructure system that offers functions and mechanisms suitable for the social, economic and cultural lifestyles of the new century.

As Japan enters the phase of the so-called matured society following the age of rapid population / economic growth, it is our national duty to accept this major transition and examine how social infrastructures should also change. In this sense, promotion of science / technology in this sector is the urgent task imposed on our nation.

③ International cooperation

Japan boasts a diverse range of software / hardware technologies for improving social infrastructures, including traditional techniques to the world's cutting-edge technologies. With past success and failure in our history of modernization, we have the potential to develop and transfer technologies that are more suited for the modernization and development of developing countries, particularly those in the Asian Monsoon area or with frequent earthquakes.

Engaging in international cooperation that takes advantage of such potential will help Japan gain the status of international standard in technologies of the infrastructure sector. This, in turn, is expected to deliver a driving force to the industry sector, and also open new outlook in the above two perspectives.

(2) Areas of Focus

For the three perspectives described above, two focal areas comprising 15 items have been defined.

① Ensuring safety

This area focuses on R&D projects for exploring human intelligence to mitigate major disasters, and for developing the environment whereby people can live their daily lives with peace of mind. More specifically, the following types of R&D fall under this category.

A. <u>Mechanisms of extreme natural phenomena</u>

Uncover the mechanism of natural phenomena, including major earthquakes, major volcanic eruptions, unusually severe local downpours and extreme drought, and develop technologies for predicting such events.

B. <u>Immediate disaster response system (disaster mitigation IT, rescue system, etc.)</u>

Develop a system for minimizing damage with a swift response to disasters and accidents.

C. <u>Measures for containing damage at major disasters in congested cities</u>

Develop technologies for containing damage (including fire prevention measures), measures to ensure smooth and swift restoration operations, and a system for supporting self-help / mutual-help efforts at the time of abnormal natural phenomena in congested cities.

D. <u>System for protecting central administration functions and cultural assets</u>

Develop a system for improving the anti-disaster aspects of social / economic activities, and protecting assets of a highly public nature such as cultural assets and science / technology research infrastructures.

E. <u>Ultra-advanced support system for disaster prevention/mitigation</u>

Develop next-generation disaster mitigation systems incorporating advanced celestial / aerial observation / communications, mobile devices, transport devices of high mobility, and anti-disaster rescue robotics.

F. <u>Intelligent Transport Systems (ITS)</u>

Develop a system for supporting effective human / commodity flows at the time of disasters and subsequent restoration operations, and also for contributing to a reduction in traffic accidents.

G. Ground, maritime and air traffic safety measures

Draw up safety measures to address changes / increase in the demands / characteristics of ground / maritime / air transports.

H. Measures against deterioration of social infrastructures

Prevent deterioration of social infrastructure facilities to prevent accidents, and extend the lifespan of such facilities.

I. Safety measures against hazardous materials, crimes, etc.

Draw up measures for resolving the negative legacy of modern times (e.g., pollution), ensuring safety against substances / systems developed in the development of science / technology, and securing safety against crimes in communal places.

② Restoring national lands and improving QOL

This area focuses on R&D projects for regenerating beautiful Japan and creating social infrastructures for higher QOL. More specifically, the following types of R&D fall under this category.

A. Rebuilding aesthetic living space in coexistence with nature

Develop technologies / systems for enhancing living space (buildings, streetscapes, public facilities, etc.) to reduce environmental strain, achieve coexistence with nature and deliver aesthetic properties.

Also, develop technologies / systems for achieving high-quality living space to enable affluent lifestyles.

B. Wide-area tasks

In the wave of increased local autonomy, devise measures to promote R&D on issues that need to be resolved among several local governments (including issues covering sea areas of multiple prefectures) so as to support their independent and sustainable development.

C. Healthier river basin water circulation system and integrated water management

While maintaining the outlook of global water management, draw up measures to rebuild water circulation system with a sustainable balance between natural and synthetic circulations.

D. Transportation system for new flows of people / commodities

Develop transportation systems for supporting social / economic activities according to new flows of people and commodities, and technologies for developing advanced transport infrastructures in congested cities.

E. Barrier-free systems and universal designs

Develop technologies / systems for building a barrier-free communal space and high QOL for all people including the elderly, disabled and non-Japanese residents, and universalizing living information of a high social nature.

F. Information infrastructure technologies / systems

Develop systems for making advanced use of GIS (Geographic Information System), internationalizing science / technology on the transfer of infrastructure technologies, and reducing language barriers to support communication in international activities.

In promoting the R&D described above, Japanese science / technology for systematic and comprehensive infrastructure development must become internationally competitive. We must promote internationally competitive R&D in Japan and with overseas partners, and make international contribution to areas of strong significance for developing countries, especially Asian nations, including anti-disaster systems, wide-area development, water utilization and transport systems.

R&D on integrated water management, in particular, is important for averting a water crisis of not only Japan but also of the rest of the world. We must conduct R&D that can contribute to Japan's initiative in global water management.

3.R&D Targets in focal areas

(1) Priority

Of two focal areas of R&D in the social infrastructure sector, priority is given to "ensuring safety". As for individual items under this focal area, their priority is determined from the perspective of protecting public lives / assets and swiftly restoring social functions.

In the second focal area, items are prioritized with an emphasis on their international nature and contributions.

(2) R&D targets

Table 1 shows key five-year (FY2001 to FY2005) targets for R&D items

Table 1: R&D targets

① Ensuring safety

Item	Key 5-year R&D target
Mechanism of extreme natural phenomena	Improve the reliability of prediction for extraordinary natural phenomena (strong motion, localized downpours, volcano under surveillance). By FY2004, complete long-term assessment of active faults and trench-type earthquakes, and compile a seismic prediction map of the entire Japan area.
Immediate disaster response system (disaster control IT, rescue system, etc.)	Complete R&D on seamless data distribution between government offices (Cabinet Office, Ministry of Public Management, Home Affairs, Posts and Telecommunications, Ministry of Land, Infrastructure and Transport, etc.), system for real-time information gathering from disaster-affected areas, and a system for providing disaster information to the public. Implement R&D of systems for disaster mitigation fiber optic sensing and communications.
Measures for containing damage at major disasters in congested cities	Complete component R&D at high-risk areas / facilities, establish a technological system and study social systems.
System for protecting central administration functions and cultural assets	Conduct component R&D and draw up system visions.
Ultra-advanced support system for disaster prevention/mitigation	Develop the vision for next-generation disaster mitigation systems, and conduct R&D on component technologies.
Intelligent Transport Systems (ITS)	Conduct R&D of the Advanced Cruise-Assistance Highway System (AHS), Advanced Security Vehicle (ASV) and data communication technologies for supporting such systems. Promote studies of international standardization.
Ground, maritime and air traffic safety measures	Reduce the 24-hour road traffic fatality to 8,466 or less, and the number of deaths and missing persons as a result of marine mishaps to 200 or less. Conduct R&D on next-generation air traffic security systems.
Measures against deterioration of social infrastructures	Establish technologies for monitoring the deterioration of large structures (including lifeline infrastructures), preventing the collapse / damage of structures, repairing infrastructures and extending the lifespan of such structures.
Safety measures against hazardous materials, crimes, etc.	Establish measures against traffic-induced pollution, contaminants, sick-house syndromes, pathogenic microorganisms, radioactive materials, waster contamination, and social crimes.

＊1 Minimum fatality (1979) since the enactment of the Traffic Safety Policies Law (1970)

Table 1: R&D targets (cont.)

② Restoring national lands and improving QOL

Item	Key 5-year R&D target
Rebuilding aesthetic living space in coexistence with nature	Conduct R&D on technologies / systems for organically or integrally improving buildings, streetscapes, communal facilities, etc. Conduct research into social systems.
Wide-area tasks	In integrally resolving wide-area issues, conduct research into 10 areas, 3 waterfront areas* and 5 sea areas** to develop beautiful and affluent areas we can feel proud of.
Healthier river basin water circulation system and general water management	In order to restore traditional beauty to our national lands, conduct R&D on improving important water systems, key rivers running through some small / medium cities, areas subject to land subsidence prevention measures*** and water circulation systems along the world's major river basins.
Transportation system for new flows of people and commodities	Explore the concept of next-generation systems for human / commodity logistics for higher QOL, implement R&D of component technologies, and conduct R&D on technologies for advanced transport infrastructures.
Barrier-free systems and universal designs	Study component technologies and systems for achieving barrier-free and universal designs for space extending over several jurisdictions, and conduct R&D on technologies / systems for universal use of social living information.
Information infrastructure technologies / systems	Conduct R&D on advanced use of GIS, and on internationalization of infrastructure technology systems.

* Tokyo, Osaka and Nagoya. ** Tokyo Bay, Osaka Bay, Ise Bay, Ariake Bay, Seto Inland Sea.

*** Northern Kanto Plain, Nobi Plain, Chikugo - Saga Plain

4.Basic Issues for Promoting R&D

(1) R&D promotion plan

For each R&D item, applicable government offices must join forces as required to systematically and efficiently promote R&D in the order of priority.

When there is a need to conduct comprehensive and integral R&D (e.g., achieving a recycling-oriented socio-economic system), concerned government offices must build and promote a unified mechanism of R&D.

(2) Priority issues for enhancing R&D quality

The social and policy aspects are extremely important in R&D of the social infrastructure sector. In this sense, it is necessary to examine social acceptance of R&D results, in addition to enhancing policy studies on infrastructure development and conducting R&D of individual areas. Studies into social acceptance include a strong field-work element. In this sense, coordination and cooperation are essential between science / technology researchers and researchers of human / social science (e.g., history, ethnography, sociology, legal studies, political science and economics).

Although steady progress is reported in the studies of areas that fit the framework of administrative organizations / systems, there is an insufficient level of achievement in continuous R&D and result application in the area across the borders of administrative organizations / systems. For this reason, efforts must be made to improve R&D activities across administrative borders.

In order to raise the quality of R&D and acceptability of their results to administration, it is necessary to promote exchange between researchers and administration, and revitalize academic societies, where researchers from the business, academic and bureaucratic sectors congregate. Exchange among researchers and with associated administrative bodies should be also encouraged for comprehensively promoting R&D of border areas. Another important issue is to develop internationally recognized award systems or thesis periodicals, so as to foster the talents of researchers and developers in the social infrastructure sector.

Meanwhile, international cooperation will help Japan set international standards in this sector, which will serve as the industry's driving force. Efforts should be made to conduct R&D that contributes to international cooperation, in a bid to fulfill the role expected of Japan. As described in 2.(1) ③, this sector has the extremely important aspect of forging partnership with developing countries to pioneer non-Western ways of developing national lands and social infrastructures. In this sense, coordination should be made with international science studies, including international politics, area studies and ethnography.

Frontier Sector

1. Current Status of the Frontier Sector

(1) Essence of this sector

The "frontier sector of space, marine, etc.", listed as one of priority areas in Phase 2 of the Science and Technology Basic Plan, has the key characteristics of "challenge from the unknown space".

Scientific studies in this sector represent the act of the pursuit of truth, stemming from the attribute unique to human beings. For this very reason, it stimulates curiosity of young minds, inviting them into the world of science and technology.

The unknown space is literally the world of ultimacy, where terrestrial norms, which mankind has been familiar with, no longer apply. Science and technology of this sector, therefore, require "breakthroughs" in the true sense of the word. In the process of conventional science / technology, based on terrestrial concepts, being upgraded for application in such an ultimate world, extreme difficulties beyond imagination will be imposed on theories, designs, materials and production / inspection processes.

Science and technology that have withstood such difficulties will bring about new breakthroughs to various sectors, and cause a dramatic leap in the standard of technological utilization / application. Numerous past examples have proven that the promotion of "frontier" R&D has an immeasurable extent of rippling effects.

Advanced technologies in sensing, positioning and communications, technologies for properly transporting such equipment, and technologies for grasping the status of sea / land areas, are indispensable for the security of the nation and its population. Their extremely significant importance should be widely recognized as a matter of national survival, rather than from the perspective of industrial / economic revitalization.

(2) Trends in this sector

R&D is conducted with close coordination between researchers and businesses, with an increased partnership of related organizations seen in the recent decision to amalgamate the three space-related organizations (NASDA, NAL, ISAS).

In terms of science, Japan has achieved the world's highest standard in the areas of neutrino, black hole, birth of the universe, exploration of the solar system and outer space, deep sea exploration, and the studies into the earth's interior and global environment, etc.

As for technology, Japan has caught up with the West in the R&D of space transportation. Yet, with China, India and other countries entering the industry, we are in the stage of polishing up our international competitiveness in terms of stable development operation and costs. Efforts are also underway to develop fundamental technologies for reusable transportation system, etc. and to ensure advanced functions / reliability for satellite systems. We have also participated in the International Space Station program to acquire various technologies utilizing a special environment, and attain manned astronautical technologies, etc.

In the use of space, Japan has reached the international level in some areas of meteorological observation, communications and broadcasting. As for the use of upper atmosphere, there are new trends in the areas of cutting-edge aircraft studies and stratospheric platform systems.

In marine development, Japan boasts the world's most advanced deep-sea probing capacity, and is leading the world in R&D of benthosic exploration. Marine observation is also conducted under international partnership, using the buoys, observation vessels and satellites of the world's highest level.

The world's fastest computer is developed for the prediction of global change, promoting the development of the leading-edge models for marine / atmospheric changes.

(3) Current status and results of measures in this sector

Results of main R&D by government offices

Cabinet Secretariat	-Information gathering satellite development
Ministry of Public Management, Home Affairs, Posts and Telecommunications	-Pioneering R&D of advanced communications networks utilizing upper atmosphere and space -Astronautical observation / research for predicting the disturbance of electromagnetic waves
Ministry of Education, Culture, Sports, Science and Technology	-Accumulation and international proliferation of the world's highest level of knowledge / technologies in space / marine related sciences -Space transportation technologies, and satellite development / operation technologies. -Development of the Japanese experiment module of the International Space Station, deep-sea drilling technologies, marine observation technologies (e.g., ARGO plan in conjunction with the Ministry of Land, Infrastructure and Transport), and deep-sea observation technologies
Ministry of Agriculture, Forestry and Fisheries	-Development of methods for identifying agricultural, forestry and fisheries resources
Ministry of Economy, Trade and Industry	-Resource exploration research using observation satellites, R&D of advanced robotic hands, and research into submarine mineral resources
Ministry of Land, Infrastructure and Transport	-Real-time monitoring of diastrophic movements, identification of damage at disasters, research into environmental monitoring, development of multi-purpose transport satellites, development of the ARGO program (in conjunction with the Ministry of Education, Culture, Sports, Science and Technology), development of basic data for land / marine GIS
Ministry of the Environment	-Development of the sensor for ozone layer observation

(4) Japan's current status and tasks for technological innovation

As examined thus far, Japan has achieved numerous outstanding results in the science and technology of this sector.

In scientific research, we lead the world in numerous areas, with further international advancement in sight.

In technology, it is widely known that Japan has overcome various handicaps and conducting development activities on par with the rest of the world.

In the area of space development technologies, we are approaching the Western level in many of its sub-areas, and are currently making all-out efforts to attain international competitiveness.
In the technologies of space use, we are becoming internationally competitive in communications satellites, etc., and are at the phase of conducting further R&D for next-generation space utilization.
As for marine development technologies, Japan has the world's highest level, as seen in our unparalleled deep-sea exploration capacity. R&D should be further conducted to refine the technologies, so as to maintain the current status and pioneer the area of marine utilization.

In relation to the business sector, we must recognize the fact that Japan now stands at the turning point of whether to turn the space industry, expected not only to be related to numerous fields of industries but also to make dramatic expansion in the international market, into one of our key industries.

2. Areas of Focus
(1) Priority areas
The Science and Technology Basic Plan stipulates that the frontier sector is fundamental to the nation's survival, calling for prioritizing areas that require government handling. In this perspective, top priority should be given to the innovation of science and technology, directly associated with national security, national border establishment, and measures against major disasters / accidents, so as to achieve a nation of safety and security.

R&D of the frontier sector is broad-based and has significant rippling effects, thus acting as the source of industrial international competitiveness. Space utilization has already become part of the indispensable foundation for national living. We must further promote the expansion and technological innovation in space utilization (communications, earth observation, etc.) for higher industrial competitiveness and establishment of the space industry as one of the nation's key industries. In marine development, past research results and cutting-edge technologies of an international level should be explored to attain and utilize useful resources.

Science / technology research projects in this sector will significantly contribute to the creation of human intelligence and fascinates young minds. Further efforts should be therefore made toward creating new knowledge. On the other hand, expanding the scale of such projects is posing increased strain on the central government, and encouraging joint undertakings across national borders. As the national policy, it is appropriate to promote international projects in which the public, especially younger generations, can find a dream, hope and pride.

Frontier R&D related to the environment sciences, in particular, will contribute to resolving many difficult problems the human race now faces. Actively disseminating information and results of such R&D to the rest of the world represents our international contribution and enables us to establish international status.

Because R&D of the frontier sector is also expected to initiate R&D of the life sciences sector and nanotechnology / material sector, close coordination should be maintained with these sectors.

At the same time, in view of large amounts of time and resources required for many of these projects, projects of strong urgency should be promoted, while those with future needs should be conducted systematically, continuously and steadily.

Based on the above issues, we have selected seven priority areas in three perspectives, out of areas supported by systematic projects with clear objectives.

① Ensuring security

Technologies for information gathering with satellites (including transportation capacity)

Technologies for advanced positioning and exploration

② Technological innovation that pioneers the world market

Technologies for saving costs and improving reliability of transportation systems

Technologies for achieving next-generation satellite systems

Technologies for utilizing marine resources

③ Making international contributions to creating human intelligence and attaining international status

International projects in which the public, especially the younger generations, can find dreams, hopes and pride

International network of information on global environment

(2) Necessity, urgency and significance for prioritization

① Ensuring security

A. Technologies for information gathering with satellites (including transportation capacity)

Essential for national security and risk management

B. Technologies for advanced positioning and exploration

Essential to achieving social effects such as national security, national border establishment, major anti-disaster measures and major accident control measures. Improvement in the capacity of industrial technologies is anticipated.

② Technological innovation that pioneers the world market

C. Technologies for reducing costs and increasing reliability of transportation systems

Fundamental technologies for space utilization, requiring urgent response to intensifying international competition. Cost saving technologies are necessary to expand long-term space utilization industries. Improvement in the capacity of industrial technologies and the creation of new industries /jobs are expected.

D. Technologies for achieving next-generation satellite systems

Contributes to building a society of an advanced information / communications network through integration with the information / communications sector, and advancing areas of transportation, national land management, environmental monitoring and resource observation. Improvement in the capacity of industrial technologies and creation of new industries / jobs are expected.

E. Technologies for utilizing marine resources

Contributes to the life sciences sector (e.g., marine microorganisms) and the energy sector through the use of new useful resources (e.g., mineral resources). Creation of new industries / jobs is anticipated.

③ Making international contribution to creating human intelligence and attaining international status

F. International projects in which the public, especially the younger generations, can find dreams, hopes and pride

Requires projects with a major contribution to mankind, those appropriately initiated by Japan under solid international cooperation, and those that can contribute to Japan's technological development.

Increased knowledge, creation of new industries / jobs and international contributions are anticipated.

G. International network of information on the global environment

Required to make international contribution and maintain international status through resolving many difficult issues in areas overlapping with the environment sector, faced by developing countries and the international community.

3. R&D Targets in focal areas

(1) Priority

Of the three perspectives, priority is given to issues for "ensuring security".

Of projects and R&D under the 7 areas and items, priority is given, needless to say, to those with urgent needs, and those strongly related to the sectors of life science, information and communication technology, environment, nanotechnology and materials.

International projects should be promoted systematically and steadily, prioritizing those with high standards from the perspectives of "public dream, hope and pride", "contribution to mankind", "international coordination" and "contribution to Japan's technological development".

(2)Target by category / item

Perspective	Category / item	R&D direction	5-year R&D target
Ensuring security	Technologies for information gathering with satellites (including transportation capacity)	Securing transportation capacity and continuous enhancement in information gathering capacity	Develop / launch satellites, and establish the technologies / systems for operation, data processing and utilization.
	Technologies for advanced positioning and exploration	Developing positioning / exploration systems, and promote their utilities / research	Establish the systems / component technologies for establishing high-precision positioning / exploration systems, and pioneering technological application.
Technological innovation that pioneers the world market	Technologies for reducing costs and increasing reliability of transportation systems	Attaining international competitiveness swiftly and developing innovative technologies for the next-generation space market	Achieve the Western level of costs and reliability for rockets, and establish technologies for achieving transportation systems with low costs / high reliability.
	Technologies for achieving next-generation satellite systems	Verifying innovative science / technology, and exploring systems for their utilization	Develop / verify ultra-fast communications technologies. Develop advanced mobile communications / broadcasting / observation / utilization technologies addressing new application needs. Verify high reliability by long term operation, etc.
	Technologies for utilizing marine resources	Exploring new resources	Identify whether new marine resources (methane hydrate, marine microorganisms, etc.) are applicable
Making international contribution to creating human intelligence and attaining international status	International projects in which the public, especially the younger generations, can find dreams, hopes and pride	Promoting projects appropriately	Conduct basic research of high quality and a progressive content to win international status and respect. Advance domestic technologies.
	International network of information on the global environment	Building a network for global environment information, mainly for the eastern hemisphere	Establish a system of international contribution through developing a data distribution system and seamless distribution of observation data.

4.Basic Issues for Promoting R&D

(1) R&D promotion program

Individual projects should be promoted systematically and efficiently, according to the priorities described above.

Of environmental sciences sector projects (e.g., R&D on the global environment), those to be promoted under the initiative of a pre-determined scenario, are closely associated with the frontier sector. The frontier sector should coordinate with the environmental sciences sector in conducting applicable R&D based on the scenario.

(2) Key issues for improving R&D quality

① Boosting national promotion of space development / utilization

Before the realignment of Japan's government offices, the Space Activities Commission served the function of coordinating space policies between government ministries / agencies. After the realignment, however, the Space Activities Commission is assigned the duty of examining projects associated with the National Space Development Agency. Since R&D on space development / utilization is extremely important as national policy, it must be promoted strongly under a long-term strategy through rebuilding a system of integral promotion.

② Development of the space industry into the core industry

In promoting R&D, the public and private sectors should establish a system of work sharing and cooperation, so that the space industry grows in to one of the core industries.

In space development, R&D on transportation systems should seek higher international competitiveness through making a stable supply of launch services and reducing costs. It is also necessary to resolve the immature side of our technological foundation, manifested in recent accidents, and fully review the past development system. Pioneering research of basic technologies is needed to bring about dramatic cost reduction and improved reliability in the future.

As for space utilization, the public and private sectors must make all-out efforts to pioneer future markets. Potential markets for the public sector include national land preservation, disaster control, transportation systems for new human / commodity flows, land utilization monitoring, urban / natural environment observation / monitoring, research into useful resources, and space utilization in international cooperation. For such public sector markets, we must step up close exchange with their user side. In order to support space utilization, the public sector should also enhance R&D in coordination with organizations in the environmental sciences sector on observation sensors and feedback systems linking the terrestrial, upper atmospheric and space systems in line with technological innovation.

Potential private-sector markets include communications, broadcasting and positioning services. In conjunction with the information and communication technology sector, it is necessary to promote future-oriented R&D that will provide new services for higher QOL. Since such R&D using the space environment will open the door to creating new knowledge / industries, coordination must be ensured with the sectors of life sciences, nanotechnology and materials.

③ Promoting application of marine development

In the R&D of marine development, the liaison conference on marine development of the Cabinet Secretariat and the council for science and technology of the Ministry of Education, Culture, Sports, Science and Technology / jointly coordinate ministries / agencies associated with marine development. From now on, we must maintain the international standard in marine research, and explore cutting-edge technologies to enhance application studies for society. Since the studies of marine microorganisms and methane hydrate, for example, are closely associated with the sectors of life sciences and energy, R&D must be conducted systematically and organizationally.

④ Resolving / predicting global environment change and applying the findings to society

Oceans serve an important role in changes of the global environment. R&D should be conducted to enhance worldwide monitoring of the environment, and develop a high-resolution simulation technology for predicting environmental fluctuations of a global scale, so as to uncover / predict the mechanism of such changes and apply the findings to society.

⑤ Fostering and maintaining human resources

With dramatic development anticipated in the frontier sector in the future, it is the urgent task to foster and ensure human resources in the science and technology areas. The matter should be addressed in the cooperative partnership between the business, academic and government sectors. In R&D for individual projects, which tend to have researchers gathered and released on per-project basis, it is difficult to heighten their knowledge standard continuously. Bearing this in mind, the R&D environment must be prepared to accommodate human resource development / maintenance.

In addition, international research exchange should be promoted through providing conditions whereby R&D staff can easily participate in overseas duties / activities.

⑥ Seamless data distribution

Much of information disseminated as R&D results in this sector, is extremely useful for other sectors and can contribute to the international community. For this reason, we must establish a system for continuously and seamlessly acquiring, processing, accumulating and disseminating information to the world. For example, information on the global environment has been accumulated intermittently by various organizations in different formats. It is necessary to make continuous observation, establish a system of continuously summarizing / processing / accumulating data, and use a common data format among concerned government offices / organizations, so as to promote the distribution and utilization of such information.

⑦ Advanced computerization

In order to improve reliability and promote lower development costs / shorter development period, we must explore foundation technologies, and establish a method / system of R&D incorporating the latest advanced information technology.

⑧ Smooth implementation of projects of international cooperation

International cooperation in advanced science / technology is inseparable from severe global competition. Concerned countries should clearly define specific contents of cooperation, so as to prevent / reduce the risk of any disputes.

⑨ Heightening public awareness

This sector represents the leading edge of science and technology. It includes R&D based on advanced specialized knowledge, and often requires an extremely large amount of funds. For this reason, we must develop technology interpreters capable of describing R&D results to the public in plain language. It is also necessary to take the approach of building up a public momentum for R&D participation, e.g. conducting active PR / public hearing campaigns.

⑩ Efficient project implementation

In view of the cumulative costs of major R&D / facility administration, we must take steps to dramatically improve the efficiency of R&D. Possible measures include forging partnership between research organizations to enhance R&D promotion, share research resources, eliminate redundant projects, and encourage the introduction of advanced IT. It is also important to evaluate major projects strictly from the planning stage, and take appropriate actions.