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Science & Technology Trends

Quarterly Review

Science & Technology Foresight Center, NISTEP

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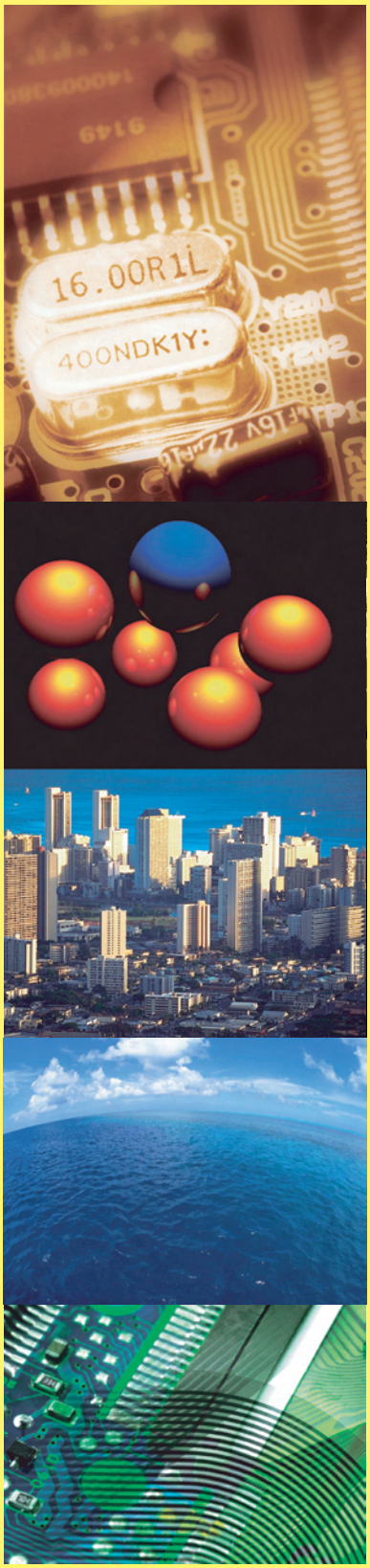

No. 29 October 2008

Science & Technology Foresight Center of NISTEP

Foreword

This is the latest issue of "Science and Technology Trends — Quarterly Review".

National Institute of Science and Technology Policy (NISTEP) established Science and Technology Foresight Center (STFC) in January 2001 to deepen analysis with inputting state-of-the-art science and technology trends. The mission of the center is to support national science and technology policy by providing policy makers with timely and comprehensive knowledge of important science and technology in Japan and in the world.

STFC has conducted regular surveys with support of around 2000 experts in the industrial, academic and public sectors who provide us with their information and opinions through STFC's expert network system. STFC has been publishing "Science and Technology Trends" (Japanese version) every month since April 2001. The first part of this monthly report introduces the latest topics in life science, ICT, environment, nanotechnology, materials science etc. that are collected through the expert network. The second part carries insight analysis by STFC researchers, which covers not only technological trends in specific areas but also other issues including government R&D budget and foreign countries' S&T policy. STFC also conducts foresight surveys periodically.

This quarterly review is the English version of insight analysis derived from recent three issues of "Science and Technology Trends" written in Japanese, and will be published every three month in principle. You can also see them on the NISTEP website.

We hope this could be useful to you and appreciate your comments and advices.

Dr. Kumi OKUWADA
Director, Science and Technology Foresight Center
National Institute of Science and Technology Policy

NISTEP has moved to a new office

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Executive Summary

Life Sciences

1 Brain Science *lato sensu*

p.9

Since the 1940s, sciences of the mind and neural system have been expanding through the integration of various disciplines. During the process of promoting these sciences as "brain science" since the 1990s, it became obvious that the proper states of brain functions and the mind should be understood as comprehensive phenomena based on interactions between brain and body, self and others, and human beings and society/environment. Today, brain science has become "Brain Science *lato sensu*." That is, it has transcended the study of the brain as an organ to become the science of 心身 (mind and body) or 心 (*kokoro* ≒ the mind).

In Japan during the latter half of the 20th century, research on "Brain Science *lato sensu*," policies to promote brain science, and neuropsychiatric disorders changed in parallel with rapid social change. It is necessary to reconsider problems that arose in this period and remain unsolved and to promote "Brain Science *lato sensu*" based on projected social needs. A typical issue is stress and mood (affective) disorders associated with rapid social change and the diversification of values.

In human beings, recognition of "the self" is constantly constructed through the interaction of perception and behavior. When perception and behavior are integrated, prospective and retrospective controls operate. Through prospective control, behavior is controlled by predictive information based on the near past and present conditions. Through retrospective control, past situations are interpreted based on current situations. Approaches such as nonlinear dynamics and psychopathology, along with conceptual frameworks inspired by them, have become indispensable in order to study these complex mental characteristics that develop and recur over time. It is necessary to promote this kind of research as part of a comprehensive national project to longitudinally study the human mind from the fetal, infant, and adolescent stages through old age.

The brain is an interface where the tangible level of the physical body encounters intangible levels such as information, meaning, spirit, and mind. The age of growth through industrialization of materials and energy alone is reaching its limits. A major characteristic of the Information Industry Age is the pursuit of social maturation based on "cerebral/sensory industries" or "spiritual industries." "Brain Science *lato sensu*" and environmental science are becoming important sciences and technologies that integrate the humanities and social sciences. They must be coordinated and promoted.

(Original Japanese version: published in June 2008)

Information and Communication Technologies

2 Technical Trends and Challenges of Software Testing

p.34

Software tests have been increasingly recognized as part of risk management and/or quality assurance in recent years. Software related problems may cause social problems, and even financial losses. It can be said that these problems are brought because of insufficient testing. Almost all machinery, including cars and airplanes, are now driven by software known as an embedded software system. In order to meet the increasing demands for testing, companies and organizations specialized and dedicated in software testing have emerged.

In the recent trend, upstream processes are incorporated into the testing methods as shown in the figure below. More importance and emphasis are given to static tests as well as test automation.

This report not only describes technological improvements, but also proposes for: 1) Sharing experiences and knowledge by establishment of a software accident investigation committee, 2) Assessment of software tests by a third party, 3) Development of legal systems for software defects, and 4) Studies on terminology, description and phrases, and proliferation of basic knowledge about software. These challenges will provide an opportunity to review the quality of systems exist in Japan including Japanese products, and have a great potential to have this activity to become so-called "quality" industry, as an activity to provide quality related processes not only to corporate organizations but also for the society in a wide range.

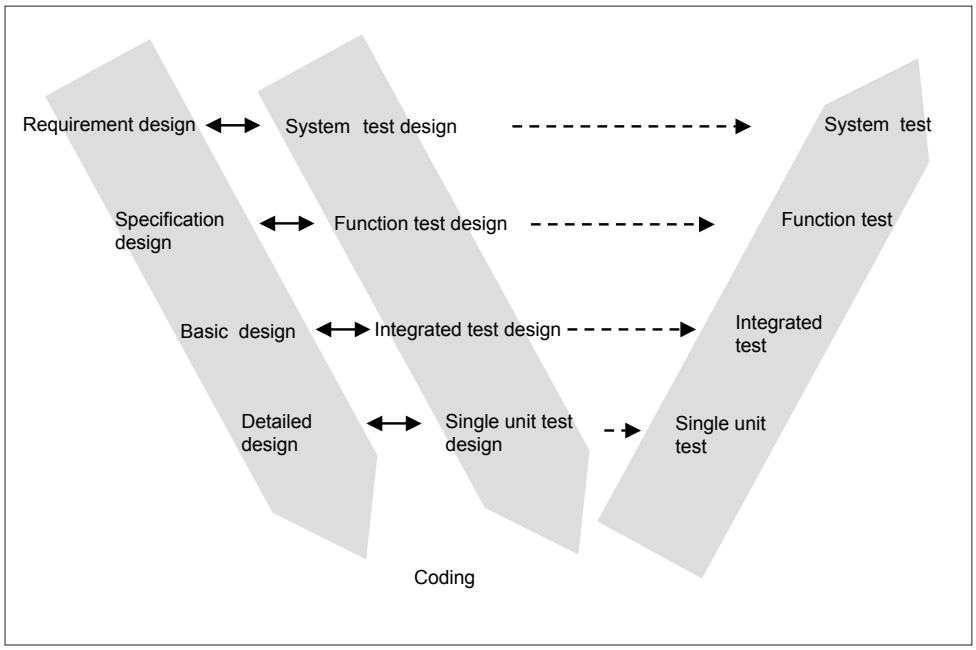

Figure : The "W"-shaped model for software development and tests (the most recent model)

Prepared by the STFC

(Original Japanese version: published in April 2008)

Environmental Sciences

3 The Modal Shift to Environmentally Sustainable Transport: Prospects of Urban Transport Systems: LRT, BRT and Buses

p.46

In 2007, the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) stated that one way to mitigate greenhouse gases emissions is to implement a modal shift from cars to public transportation. To make this happen, it is vital to develop policies that push for change in the lifestyles and behavior patterns of car-dependent societies. The environmentally sustainable transport (EST) concept, which the OECD developed in 1996, presented different viewpoints regarding public health and socioeconomic concerns, as well as greenhouse gases. Today, Japan acknowledges the EST as an appropriate means to mitigate global warming, and a key to achieving a compact city in the future.

In Japan and abroad, new urban rail systems called Light Rail Transit (LRT) and articulated buses known as Bus Rapid Transit (BRT) are being actively introduced to many cities as a part of the EST initiative. These rail systems operate at speeds close to that of a monorail, while only costing 20 to 50 percent of what it would cost to build one. For this reason, LRTs and BRTs are expected to bridge the transportation gap and improve the quality of public transportation. Aside from their futuristic appearances, they are equipped with new technologies such as low-floors and onboard IC-ticketing systems. Furthermore, battery-equipped vehicle technologies, which enable them to operate without feeding power from outside of the vehicle, are rapidly making headway.

Future societal needs formed the concept of a public transportation system that is both safe and environmentally friendly, while contributing to the development of compact and lively cities. If we further improve the technologies that make lives more convenient and increase the societal benefits, we will be able to accelerate the modal shift toward public transportation and put an end to our car-dependent society.

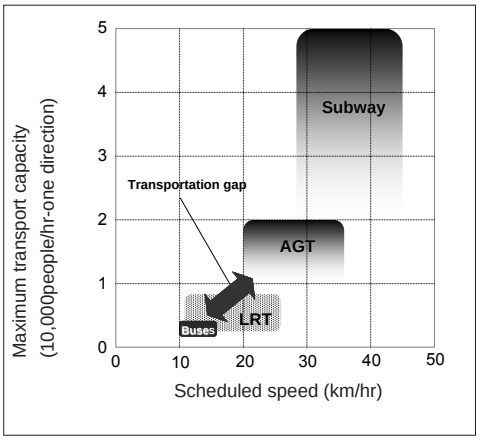

Figure : Capability of public transportation
Prepared by the STFC based on Reference[6]

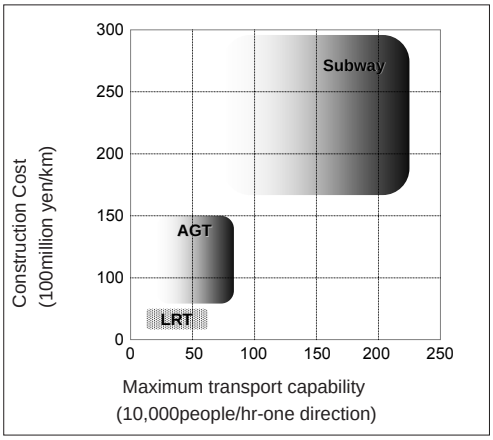

Figure : Construction cost of public transportation
Prepared by the STFC based on Reference[6]

(Original Japanese version: published in May 2008)

Frontier

4 Ocean Science and Technology in the Starting Marine Management Era

p.62

The ocean has been used widely and freely for long time, though this idea has been reexamined and a new framework has been established to manage the ocean in recent years. Furthermore, the role of the ocean in regard to global environmental problems is beginning to be recognized. In Japan, the Basic Ocean Law was established on July 20, 2007 in order to respond to this era of marine management. The Basic Plan on Ocean Policy was resultantly established on March 18, 2008 as an agenda of measures for the next five years, to ensure that measures concerning the ocean are implemented in a comprehensive and systematic manner. The policy aims of the Basic Plan are: (1) to be a pioneering challenge to the issues of the oceans that affect all of mankind, (2) to lay the foundations for the sustainable use of the oceans plentiful resources and space, and (3) to make a contribution in the oceanic field toward the realization of a safe and secure national lifestyle; and it also clearly shows a shift in the basis of the policy from a "use-the-ocean perspective" to a "manage-the-ocean perspective".

This means the dawn of a marine management era is here for Japan, and ocean policy will be developed from a "Marine Nation" perspective. Some of the issues facing oceanic scientific research and technological development: the cultivation of excellent researchers, provision and/or improvement of a platform for leading-edge research surveys, and the nurturing of experts to put these into effect.

It is expected that Headquarters for Ocean Policy newly established in Cabinet, shows top-down leadership in advancing Japan's oceanic strategy, by becoming a coordination institute with respect to each oceanic measure that the various agencies and ministries are responsible for implementing, and also shows this kind of leadership toward the policy issues that need to be promoted as National Basic Policies. Furthermore, that 'Ocean' is not restricted to the small area within Japans' Exclusive Economic Zone (EEZ) etc. so that it is able to widely 'connect' with the world through the entire ocean on the Earth, and that Japan's Policy on Marine Science Technology becomes a model for the world.

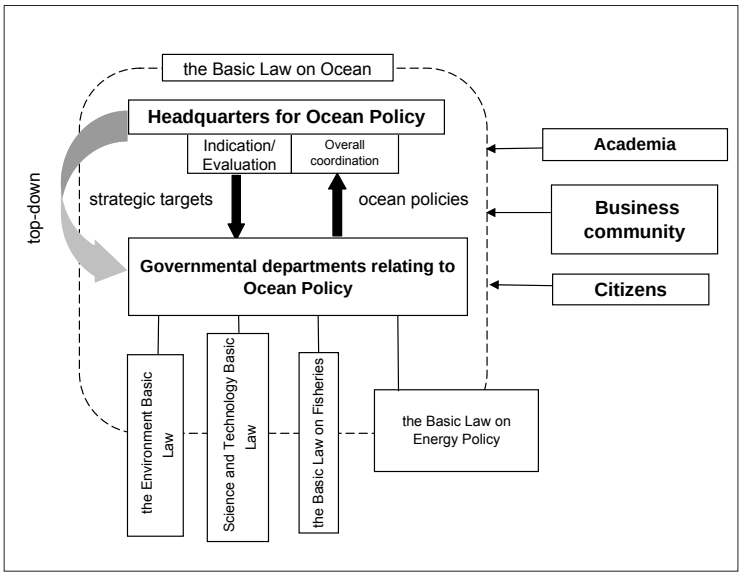

Figure :Top-down leaderhio expected to the Headquarters for Ocean Policy
Prepared by the STFC

(Original Japanese version: published in May 2008)

Science & Technology policy

5 Initiatives for Innovation Measurement by the US Department of Commerce (DOC)

p.76

On January 18, 2008, the United States Commerce Secretary Gutierrez called for action on innovation measurement based on the report entitled "Innovation Measurement, Tracking the State of Innovation in the American Economy" by the Advisory Committee on Measuring Innovation in the 21st Century Economy.

This initiative has a couple of features; (1) The investigation was pursued under the government's recognition that innovation is an economic driving force. It would be necessary for policy makers and the people to understand the impact innovation has on productivity and economic growth, in order to apply appropriate policies. (2) The committee members, selected from the top down, included influential business leaders, as well as eminent researchers. (3) Actions not only by the DOC, but also by cross-government, private sector, and academic circles are required.

First of all, the report defines innovation as "the design, invention, development and/or implementation of new or altered products, services, processes, systems, organizational structures, or business models for the purpose of creating new value for customers and financial returns for the firm," and the recommendations below follow.

[What the government should do]

-Establishing a framework for identifying and measuring innovation, such as the improvement of the measurement of intangibles and Total Factor Productivity measurements at industry level

[How the business community can help]

-Develop the best practices for innovation measurements, and also make innovation-related information available for the researchers

[Where the research is needed]

-Measurement of outcome of innovation

-Identifying insufficient innovation data and the way to fill it

-The analysis of relations among innovation performance, collaboration, innovation activities, and the corporate performance

In recent years, more and more policies focusing on innovation have been formulated in many countries. Along with these, the movements to measure the effects of innovation policies and innovation itself for the benefit of policy formulation and implementation have increased. In the United States, two initiatives have been moved forward under cooperation and role-sharing of the NSF and the DOC: the development of Science and Engineering Indicators and funding for related research have been carried out through the NSF's (The National Science Foundation) "Science of Science and Innovation Policy" program, and the development and measurement of economic statistics by the DOC. We have to continuously pay attention to these trends and progress as an example of an inter-ministerial cooperative approach for innovation measurement.

(Original Japanese version: published in April 2008)

6 Report on the annual AAAS Forum on Science and Technology Policy

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The AAAS (American Association for the Advancement of Science) held the 33rd annual Forum on Science and Technology Policy in Washington D.C on May 8-9, 2008. The AAAS is one of the largest international non-profit organizations with members that consist of scientists, science educators, policy makers, and others. At the forum, the focus was on the presidential election and beyond. The plenary sessions covered topics as follows; "Budgetary and Policy Context for R&D in FY 2009", "What Kind of World will Science and Technology Face - and Help Create - in the 21st Century?", "Science and Technology, the 2008 Election, and Beyond", and "Science and the New Media".

At the session; "Budgetary and Policy Context for R&D in FY 2008", the keynote address was given by John H. Marburger, the Director of the Office of Science and Technology Policy. He encouraged scientific community to make an early start to be involved in science and technology policymaking before the new administration begins to function. He further pointed out issues such as the lack of management framework for R&D budget allocations in the U.S. and the imbalanced budget allocation among fields. This was followed by Kei Koizumi, the Director of AAAS R&D Budget and Policy Program. In his analysis of Federal Budget Proposals for FY 2009, he showed that budget allocations were in line with the American Competitive Initiative and America COMPETES Act.

Other sessions, such as; "What Kind of World will Science and Technology Face - and Help Create - in the 21st Century?" and "Science and Technology, the 2008 Election, and Beyond" indicated that the next administration needed to tackle climate change, energy issues, and other global-scale issues by rallying scientific knowledge and technologies from around the world. The session, "Science and the New Media", showed the potential of blogs and virtual worlds as a means of science communication.

(Original Japanese version:publishd in June 2008)

1

Brain Science *lato sensu*

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1 Introduction

Today, the implication of the term *brain* is expanding. For conditions endogenous to neuroscience/psychiatry/neurology, it is clearly impossible to describe the development and functions of the brain or states of mind only in terms of the brain as an organ. Research now underway is based on interactions between brain and body, self and others, and human beings and society/environment. Since the latter half of the 1940s, various methodologies and bodies of knowledge have been combined and integrated to create an academic field that can be called "Brain Science *lato sensu*" (hereinafter, "Brain Science"). This area is still expanding.

Meanwhile, exogenous factors are also raising social expectations for Brain Science. First, in 1963, UMESAO Tadao recognized the arrival of the Information Industry Age, which he also called "cerebral/sensory industry".[1] He advocated the importance of not only information that works upon the intellect but also of sensory information, which works upon the senses, and of experiential information, which comprehensively stimulates the five senses. In recent years, the importance of sensory and experiential information has been increasing. UMESAO also predicted that the spiritual industry would succeed the information industry. As society realizes the limits of its reliance solely on growth through the industrialization of materials and energy, it has become necessary to shift to the pursuit of sustainable maturity through the spiritual industry.

In 1969, TODA Masanao[2] predicted that an aging society could not assimilate accelerating changes and excess information, and that dissatisfaction would grow along with affluence.

The urgent task of humanity is therefore to create a society where each affluent individual can directly participate in cycles of information-acquisition and their feed-forward control (i.e., creative processes). Psychology (today's cognitive science), he predicted, would play an important role in achieving this.

Beginning in the 1990s, people became aware of the weakening of common values, information overflow, and opacity in society. After 2000, Japanese people have come to long for the following in the coming decades: the healthy growth of their children, lifelong opportunity of learning, tolerance and diversity in society, a society that pursues spiritual affluence, state of 自足(humble satisfaction with life), autonomy and satisfiable quality of life for the elderly and disabled, and a safe and secure society.[3] Supporting people through the development of Brain Science is an important issue for government in order to respond to these desires.[4]

The brain is an interface where the tangible level of the physical body encounters intangible levels such as information, meaning, spirit, and mind. Brain Science is an important venue for discussing the intersection between empirical natural science and academic fields that address the emergence of meaning. From the perspective of changes in science, technology, policy, and society, this report will discuss the process by which "Brain Science *lato sensu*" was formed and the themes that “Brain Science” should henceforth address.

2 Research areas comprising Brain Science

Until the first half of the 20th century, studies of the mind, nervous system, and 心(*kokoro*) in natural science were performed independently in disciplines such as psychiatry, anatomy,

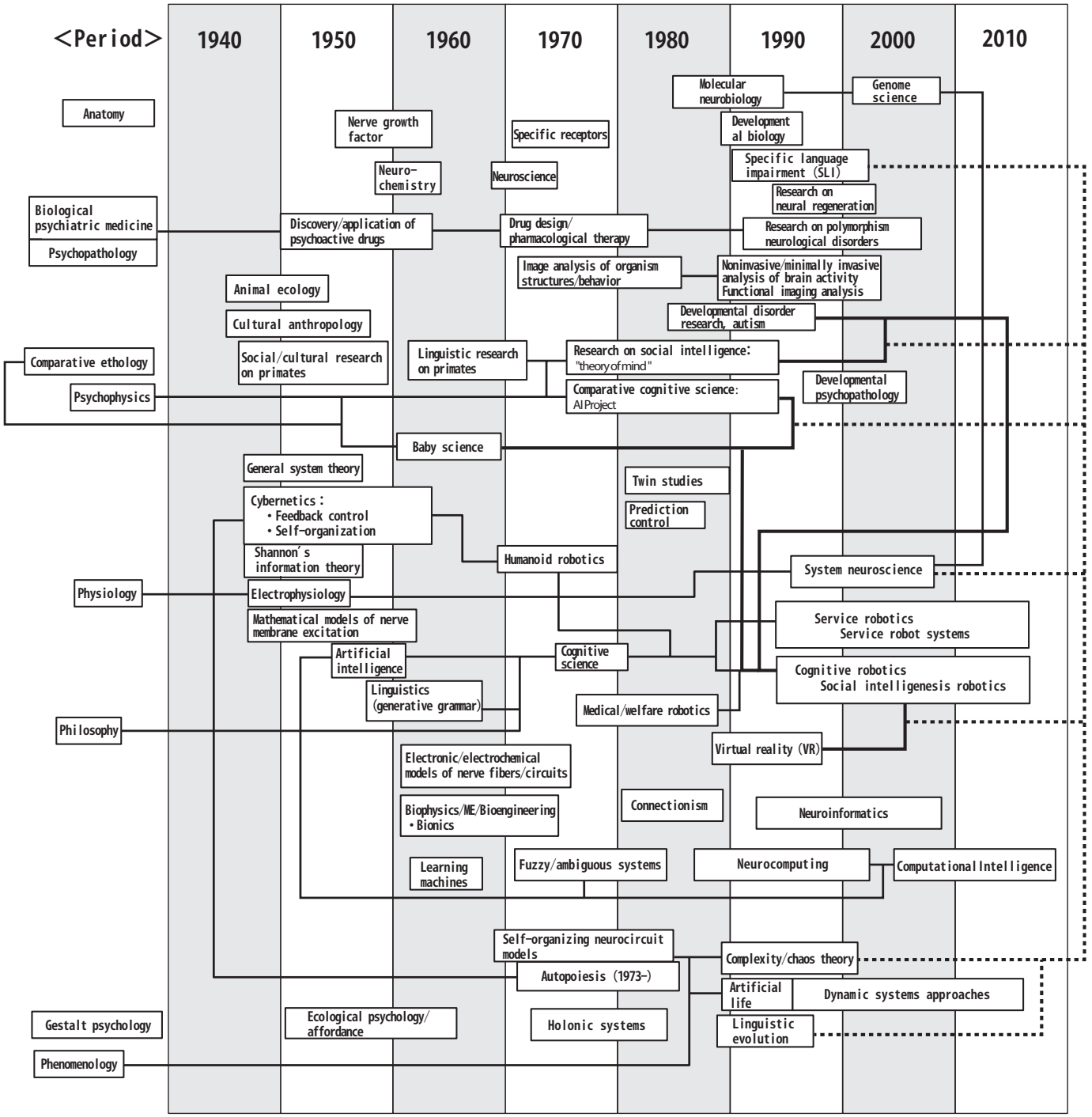

Figure 1 :The formation of Brain Science

Prepared by the STFC

Figure 1 depicts an overview of the flow of association and integration of various types of research related to today's Brain Science. The left end of each box approximately indicates the dates of initial announcements of the theory or formation of schools described in the box. From the top, Figure 1 generally classifies research categories: 1. molecular biology and genetic analyses, 2. studies on human and monkey individuals and groups, 3. engineering & computational neuroscience such as robotics (mainly approaches based on internal models), and 4. research based on nonlinear dynamics, complexity, and chaos. Comparative studies on the development and its perturbation of humans, monkeys, and robots in communities and societies thereto are being carried out beyond the general categories and generating significant knowledge (bold lines). Research in areas that use nonlinear dynamics will become increasingly important for analyzing individuals with different personalities and characters and mental states fluctuating in real life. The dotted lines indicate association and integration expected in the future. Association and integration of psychopathology and behavioral genetics with twin studies, long-term longitudinal research, and virtual reality (VR) are expected. Their connection is not indicated in Figure 1 because of complexity. Today, the birth of cognitive science is often attributed to a series of conferences and articles in 1956, but the date it was established as academic communities (societies) is indicated here in the 1970s[5]. Although some studies, twin studies for example, have a long history, the time when methodologies similar to those used today were established is shown.

physiology, and psychology. After World War II, concepts, theories, and researchers from fields of physics, engineering, and information science, such as cybernetics, have been introduced in this research. Furthermore, methods and concepts from biochemistry, pharmacology, molecular biology, developmental biology, and genetics were successively introduced, and many researchers from those fields joined in the work. Meanwhile, fields such as computer science, linguistics, psychology, and philosophy formed cognitive science, and the boundaries between it and brain/neuroscience have been falling in recent years[5]. There have been methodological advances in fields such as psychophysics, measurement and visualization of brain activities, and cognitive psychology. Research on the functioning of healthy intact individual humans and other primates is also progressing. (See Figure 1.)

The accumulation of diverse knowledge and methodologies and the ability to process vast amounts of information at high speed with computers, along with collaboration among researchers with varying perspectives, have led to results such as the following.

1) Systemic scientific analysis connecting different levels such as molecules, cells, modules, functional areas, and the central and peripheral nervous systems has become more important.
2) Simulations from appropriately macro perspectives to understand mental phenomena without reference to micro-levels (creation of intelligent life/constructive approaches) have flourished. Broadly speaking, there are two motivations.
   - Researchers discovered that characteristics of entire systems could not be defined due to the nonlinearity and complexity of the brain, even when lower-level information such as molecules and neurons was integrated.
   - In pedagogic, medical (such as psychiatry) and vocational venues, holistic rather than reductionist descriptions are desirable.
3) More researchers began to tackle themes such as gestalt perception, linguistic and cognitive evolution, decision-making and free will, consciousness and unconsciousness, and the construction of self, which were previously difficult to study empirically. Hypotheses and ideas that had not been investigated by the majority of researchers because they were considered too avant-garde, abstruse, or premature (e.g., G. B. Vigo, C. S. Peirce, G. Batson, the origin of language, B. Libet) are therefore being reevaluated. This is creating environments that promote empirical research.

Among the above changes, some newly discovered knowledge relevant to Brain Science and some new issues garnering attention include

the following.

1) Awareness of self and others

In addition to clinical research on disease and injury cases, psychophysics studies on healthy humans have found that awareness of self and differentiation between self and others are variable. Awareness of the self is continually constructed through the interaction of perception and behavior.[6–7]

2) Understanding of the behavior and intentions of others

Mirror neurons, which were discovered through electrophysiological research on monkeys, contribute to interactions between self and others in terms of understanding the behavior of others, constructing self-body–image according to that, and actual imitation/emulation. Psychology experiments using noninvasive measurement of brain activity in humans have found similar phenomena, suggesting the existence of a mirror neuron system for the imitation of others and the understanding of their intentions.[8]

3) Free will and decision-making

Recognition that one makes intentional judgments and choices may be an ex post facto explanation for phenomena that occur in the brain and body. For example, the existence of readiness potential, which occurs in the brain some hundreds of milliseconds ahead the intention to act, is well-known.[9–10]

It is understood that there are two types of decision-making systems, a system for making statistical judgments and a system for making judgments based on individual history and present circumstances.[11] Reproducibility has been fundamental to empirical research since Bacon, yet these studies support the phenomena that human beings can obtain firm ideas in just one moment.

4) Backward Referral and Prospective Control

Time perceived by human being's first-person sense actually have a certain range from the moment called "now" to the past just before "now" and the projected future immediately after. Behavior is inevitably accompanied by prospective control such that humans may ignore the difference between prospect and reality as far as it is within allowable limits. This suggests normal prospective control may share basic mechanisms with the sense many people with schizophrenia have that “their minds are read and seen through by others,” “their actions have already gotten ahead,” and “they are conducted to” act.[12–13]

5) The bases of forming social relationships

During infancy humans develop a "theory of mind" to estimate and understand the intentions and feelings of others. Studies on people with autism who have certain difficulties in this development, accelerated analysis of bases for forming social relationships with others from the viewpoints of Brain-Science.

6) The roles of affect/emotion

Neural mechanisms[14] and cognitive functions of emotion/affect, the physiological significance of psychological stress, and the role of emotion/affect in decision-making.[15] Biological research on psychological stress has been carried out from the perspective of basic biological reactions (stress reaction) by living subjects to maintain homeostasis in the face of external stimuli.

In addition, the following are also examples of areas where technological development has occurred within Brain Science.

1) The proliferation of noninvasive measurements of brain activities has lessened the distance between brain/neuroscience, which studies the brain as object, and cognition science, which studies information processing processes within the brain.

2) The discovery of neural stem cells in the brains of adults has increased the possibility of clarifying structural changes in individual brains according to personal cognitive history.

Ongoing and new research themes for Brain Science that deserve promotion include the following.

1) Elucidation of mechanisms for constructing the self and its quasi-continuous awareness based upon relationships with other conspecifics;

2) Elucidation of the phenomena of individuals with different personalities and characters, not just

of universal human characteristics;
3) Elucidation of the process by which various cognition and behaviors are generated or halted, in addition to descriptions of states when a certain response to a specific test is stably taking place;
4) Elucidation of the emergence of a subjects' actual feelings and meaning based on her/his propensity, memories, and experiences and of the ways meaning is generated, rather than descriptions of phenomena described from outside;
5) Research that proceeds from the prospective of linking Brain Science to the elucidation of life itself and of mechanisms for maintaining ecosystems.

3 The forming of Brain Science

This report discusses how disciplines were combined and integrated to form Brain Science, what can be understood from this process, and potential developments in Brain Science.

3-1 Brain Science in primates

Primatology in Japan began in about 1948, with research on Japanese macaques based on animal ecology and cultural anthropology. The identification of individual monkeys combined with longitudinal observation was pursued to extract essential factors of society through changes in relationships among individuals.[16] The creation of cultures such as familial systems or tool uses, their propagation, and changes are analyzed. This comparison with monkeys shed light on the notion that the family system of human is quite unique to human beings. For example, not only children and their mother but also the father and grandparents live together, and furthermore also members of the community provide support from outside the family. In Japan, Japanese macaques are often used in electrophysiological research to study changes in body image and cognitive patterns associated with tool use. Similarities and differences of results obtained for them and for humans are compared.[7]

Some propose a hypothesis in which the postmenopausal lives of individuals have lengthened in order to "create grandmas" as a childrearing strategy in humans. In anthropology as well, an important concept is the idea of tense relationships ("avoidance relationships") between close generations such as parents and children and "joking relationships" between more distant generations such as grandparents and grandchildren that allow teasing or frank talk about topics usually considered socially inappropriate. This is believed to exist even today in many societies, including some Asian ones. In Germany, researchers are conducting a study based on the perspective that living with younger people benefits in turn the health of elderly people.

Research on the minds of chimpanzees, which began in the occident early in the 20th century, has progressed in two directions following the language research of the 1960s–1980s, i.e., research on social intelligence and on comparative cognitive science. In social intelligence research, "theory of mind" is a major theme. As in research on human developmental psychology and autism, studies of empathy, social reference, imitation/emulation, and joint attention are underway.

Meanwhile, comparative cognitive science such as Japan's AI Project applies psychophysics methodology to the scaling of sense and perception in order to measure color sense, visual acuity, number concepts, and memory capacity. While psychophysics has been used to study mainly adult humans since the 19th century, in recent years it is often used in studies of babies, who are hardly instructed or trained verbally, or unable to respond verbally. The same scales can be used to analyze functions of robots too. This enables comparisons of the cognitive functions of humans, chimpanzees, and robots.

Research is underway in cognitive archeology on analysis of changes in human cognitive patterns accompanying evolution, changes in living environments and social structures. Other research is focusing on analysis of the genomes of modern humans, Neanderthals, and other primates, and on the comparative development and behavior of human beings and other primates. The ensemble of these studies will enable understanding of interaction between cognitive change of humans, creation/use/improvement of tools, and exploitation/reformation of environments.[17]

With a notion that it is no longer the time to focus only on primates and it is essential to promote research on entire ecosystems, Kyoto University is reforming its Primate Research Institute and its outdoor observation facilities based on this

idea. In the USA, large primate research is a key notion of the movement advocating a "Decade of the Mind" initiative following the "Decade of the Brain" (1990–2000) and "Decade of Pain" (2001–2010) initiatives[18] and of CARTA, the Center for Academic Research and Training in Anthropogeny ("anthropo" + "geny"), which aims at elucidating human diseases from an evolutional point of view and was launched in FY2008 based at the University of California at San Diego (UCSD) and the Salk Institute including an internet-based virtual research center.[19]

3-2 Physics/engineering/information science/ mathematics theory

Based upon the progress of electrophysiology since the end of the 1940s, followed by the spread of cybernetics, research on biological information processing inspired by Shannon's information theory, and the improvement of electronics, which enabled detecting weak biosignals, and processing and calculation of large data, bionics emerged during the 1960s combining biology, physics, engineering, and mathematical science. Because the characteristics of neural systems as control machinery and the morphology, electrochemical characteristics, and networking of neurons were attractive for engineers, vigorous modeling and empirical testing have begun. Through medico-engineering collaboration, research on artificial neuron/organs, remote detection of in vivo information, and learning/memory of machines has started.[20]

In the 1970s, research on humanoid robots with a computer as the brain and mechanical actuators as the body began. As demand for rehabilitation increased, and Japan's aging society arose as a social issue in the mid-1970s, Japanese researchers quickly launched research on medical and welfare robotics, including prosthetic/nursing equipment and "guide dog" robots.[21–22] These approaches have developed into research on service robotics, service robot systems, and virtual reality (VR) today.

The 1990s saw the beginning of robotics research to study human cognitive functions and bases of development and social intelligence through constructivist approaches that create functional systems and verify cognitive and behavioral models within the systems.[23] This is an important methodology for the elucidation of the mechanisms of human problem-solving and communication in a complicated and unpredictable real world.[24] In the past, robots were considered just objects to be manufactured and used in closed environments such as laboratories and factories. Japanese robotics researchers and companies in the 1990s came up with the innovative concept of conducting research and development of robots, which were projected for direct contact with the general public in their daily life.

As research and production facilities, transportation, information, and decision-making systems grow larger and more complex, it has become clear that even with the advancement of mechanical control systems, risk of disasters cannot be eliminated because of human factors such as neglecting, ignoring, or mixing up procedures through inattention, misunderstanding, fatigue, or over-habituation. Thus, human-machine interfaces are being improved and VR-based training systems are being developed based on understanding human cognition and behaviors.

3-3 Nonlinear dynamics, self-organization, and complex systems

A concept of ‘self-organization’ was discussed in Wiener's "Cybernetics" besides ‘feedback control.’ In 1954, KUBO Ryogo (University of Tokyo) and TOMITA Kazuhisa (Kyoto University), et al., pioneered nonlinear physics, and they have been followed by a number of leading researchers. In recent years, research on artificial life has also flourished in this context.

In the early 1960s, NAGUMO, an expert on nonlinear oscillators, created an electronic-circuit model of nerve fibers using a tunnel diode based on the Hodgkin-Huxley’s mathematical model of the excitation of the neuronal membrane. He also created an electrochemical model of the reverberation of excitation patterns. These models became one of cues for following bionics research in Japan.

In 1973, neurophysiologists MATURANA and VARELA conceived the idea of autopoiesis[25]. This theory describes life from an internal perspective rather than that of an external observer. Although the theory has yet to prove anything, it has been

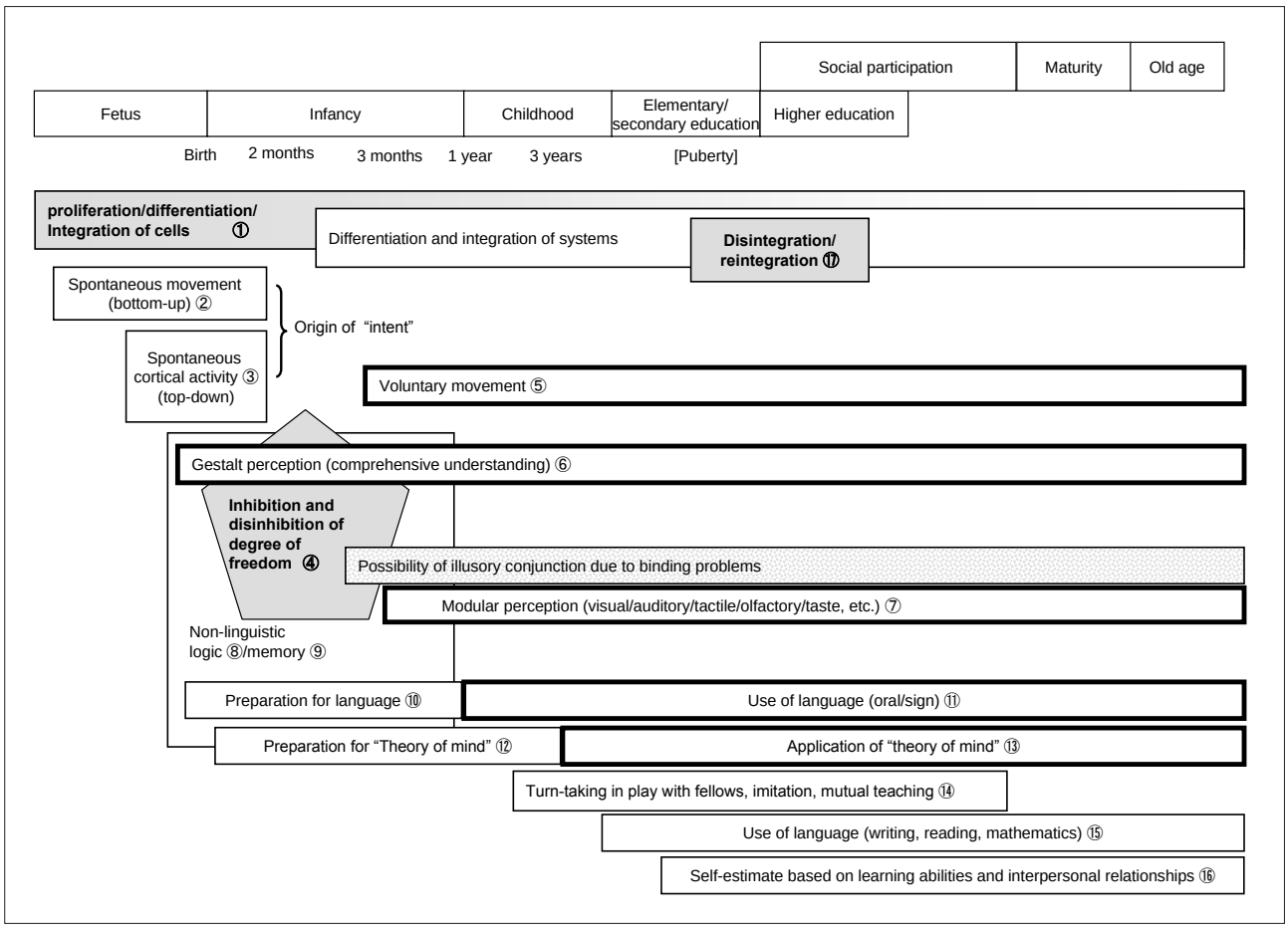

Figure 2 :Differentiation and unification of nerve/body system in life

Prepared by the STFC based on References[29-31]

The multiple factors associated with difficulties, disabilities, or diseases that may (or may not) manifest with growth may have their synchronously roots or tend to interact among them in certain stages of development. Long-term and longitudinal perspectives must be taken based on entire human life history while making good attention on turning points of growth from scientific viewpoints.

incorporated into concepts in artificial life, robotics, and virtual reality for education and medical treatment.[26–27] It is expected to obtain proofs through simulations and real-world verifications in these fields. As the concept is relatively plausible in the description of the neuronal system, expectations are high that novel ways of understanding life may emerge and be propagated from understanding the brain and cognitive functions with the theory.

In Japan in 1978, SHIMIZU Hiroshi advocated holonic systems.[28] In 1986, regarding models of cerebral visual pattern cognition he proposed that the interpretation of meaning emerges through the interaction of top-down and bottom-up signals and the information self-organizes in the brain. In 1990, TSUDA Ichiro reported a chaotic itinerancy phenomenon in neuronal circuit models. This has garnered attention in relation to dynamic associative memory in the brain.[29]

Nonlinear dynamics is applied for the elucidation of developmental process of fetuses and infants in recent years. (See Figure 2 for {1–17})

Simulations are being conducted on the processes through which the immature nervous systems of fetuses cause physical movements, find various patterns of spontaneous movements, and based on such repetition, the cerebral cortex comes to self-organize while reflecting physical structure (3).[31] The hypothesis that during a newborn's U-shaped development, after decreased freedom at about 2–3 months (4), gestalt perception (6) shifts to modular perception (7) controlled by intention in the cerebral cortex[29] is being investigated. The development of foundational ability in the preparatory stage (10–12) for voluntary use of language (11) and application of "theory of mind"

(13) is also being analyzed.

The following are some themes that should be promoted in the framework of Brain Science.

a) Nerve precursor cells undergo active division and proliferation in fetuses. Precursor cells, which have had some degree of freedom, differentiate during this process into neurons with various degrees of freedom. The mechanism by which robustness of the entire system is generated through the interaction of neurons that have differentiated from similar precursors can be studied (1).[29]

b) The hypothesis that voluntary movement (5) is generated when the freedom of spontaneous movement originating from the subcortical neural activities (2) is once suppressed by spontaneous activities of the cerebral cortex (3) is momentarily inhibited and then released.

c) The risk of imperfection in selective attention and illusory conjunction during the shift from neonatal gestalt perception (6) to the additional state with modular perception (7), and its presumable relationship with future synesthesia and dyslexia (15). The relationship between gestalt perception and synesthesia.

d) The relationship between nonlinguistic intellect and linguistic- and social intellect.

• Elucidation of logical deduction in infants before they use language (8) and elucidation of the mechanism for generation of stimulus equivalence which is illogical but characteristic of human beings and contributes to higher-order cognition such as symbol use (15).

• Development of nonlinguistic memory (9). The relationship between gestalt perception and synesthesia (c) with the "grounding of

Why are non-linear dynamic approaches necessary?

Because human neuropsychiatric systems have the characteristics described below, analysis using nonlinear dynamics is advantageous.

The brain is nonlinear: The brain is a nonlinear system and it is impossible to determine its characteristics by adding up information in sub-layers such as molecules and cells. Reductionist approaches such as molecular biology that separate the system into (material) parts for study therefore cannot address some aspects of the brain. Furthermore, due to non-linearity in the generation of perception and behavior models, learning may not be achieved successfully only by imitation of others using the forward-reverse relationships of the models.

Generation of movement and perception: In most simulations of human behavior using robots to date, robots lack autonomy or motives. Generally, engineering and computational approaches take the existence of goals for granted, and researchers externally set goals for robots (for example, imitating human movements). It is therefore often impossible to study the mechanisms by which movement and perception emerge. Assuming control solely for purposefulness, improper configuration due to excessive freedom becomes the problem. Restrictive conditions must then be introduced to avoid this situation.

People often act non-purposefully: Most human behavior is not purposeful. A certain part of it is, at the same time, purposeful and it is difficult to distinguish. Goals, attention, and interest shift during the processes of action and perception. Subjects and rules change during conversation and games. Natural human activities rise, go on and cease including these fluctuations and flows.

Generation of meaning: Information that enters bottom-up from a sensory organ is polysemous, and top-down mechanisms act on it to attribute certain meaning to the information. Moreover, human brains demolish perceptions of a meaning after they have been fixed, replacing them with other sets of perceptions with deferent meanings (e.g., switching the figure and ground of a visual stimulus). Human beings thus do not objectively recognize events or objects existing outside of themselves as they really are, but instead segment and interpret them (to create meaning).

Temporal development: A human being's subjective sense of time comprises the moment called "now" in series with the past and the near future. The flow of time is supported by embodiment, morphology, experience, memory, and so on.

References[28–30]

memory."

• The mechanism that the entrainment into languages games takes place based on premature linguistic (10) and social (12) abilities and that it shifts to voluntary speech (11).

e) • The mechanism by which infants shift from understanding the "theory of mind" of others to understanding a "theory of mind" for themselves (13).

• Turn-taking of roles and rules during play, imitation, and reciprocal teaching among fellow infants (14).

f) • The mechanisms by which meta-cognition about one's own ability develops at the age of approximately 9 or 10, and self-esteem develops due to complex factors including the meta-cognition and social interactions with others. In addition, the mechanism by which difficulties with reading and writing may hinder this development.

• The mechanisms by which the abovementioned systems disintegrate and reintegrate along with drastic physical changes including the nervous system during adolescence (17).

Furthermore, in order to study correlations among these various phenomena and their relationships to latent difficulties, disorders, and diseases that often manifest only after a certain interval, it is necessary to outline a long-term project of longitudinal research from an early stage and to promote various research under the context of this project. Additionally, comparison with primatological research on the development of young chimpanzees and monkeys would also be effective.

Following the dynamic systems approach advocated by Thelen, et al., in 1994, in fields of developmental research and developmental psychology, the analysis of macro phenomena are being carried out inspired by concepts of nonlinear dynamics and using them in the figurative sense. It would be useful to watch the future progress of such analyses and to take up phenomena that can be subjected to strict analysis using genuine nonlinear dynamics and to design appropriate research projects.

3-4 Brain Science linked from molecular aspect

Various neurotransmitters were identified in the 20th century. An academic society for neurochemistry was founded in 1958 to seek out molecular changes as the causes of mental illnesses that take place without any obvious changes in macro morphology. Around 1970, an academic society for neuroscience was founded. Psychotropic drugs were discovered in 1952, and their clinical application began, contributing to the progress of neuropharmacology. During the 1970s, endogenous opiate receptors were identified, drug design became full-fledged, and pharmacological treatment of mental illness expanded. Analysis of interactions among neural substances began through the adoption of molecular biology methods during the 1980s. Starting in the 1990s, system scientific approaches became active where research at the molecular level, physiology and information science are integrated.

Furthermore, introduction of methodologies and personnel from developmental biology led to analysis of the structures and functions of the neuronal system from viewpoints of ontogeny and phylogeny. In clinical medicine, although it was already known that development of intelligence, linguistic ability, social interaction, and conduct abilities can be perturbed by neurological factors, developmental studies on cognito-psychological functions and brain activities began in addition to the traditional studies depending solely on brain autopsies. Research on autism and specific language impairment (SLI) has not only contributed significantly to understanding higher-order functions in humans, but also provided useful conceptual frameworks for robotics. An example of progress for such research is the understanding that underdeveloped abilities can be improved with training. In recent years, this has been discussed also in the general framework of school education.[32]

Positional cloning has identified genes related to psycho-neuronal disease. Genes related to specific language impairment have been identified through familial studies of high incidence. Phylogenic analysis of such genes inspired research on cognitive evolution and language evolution.

Furthermore, simulation of the action of classical

neurotransmitters and the neural networks conveying them is being used to study behaviors such as expectation, exploration, and learning in cyber-rodents. This research connects molecular science, engineering, and behavioral science.[33]

4 Brain Science in Japanese science and technology policy

In Japanese science and technology policy amidst the social changes from the post–World War II reconstruction, the rapid economic growth to the present age of diversifying values, Brain Science has been promoted as an important research area in order to prepare for predicted future social circumstances and to meet social needs.

In recent years, increasing numbers of cases are seen where conditions in the real world largely affect the directions of research projects, or scientific knowledge and technologies come to their maturity only being practically applied in society. This has narrowed the gap between research and the real world. Brain Science is no exception.[34]

During the 1990s, as ministries and government offices began to boost research from various interests in brain science, the timetable for strategic goals based on 'the long-term perspective on brain science research and development' was settled. An overview of policy trends that have affected Brain Science is described below.

4-1 Changes in welfare, healthcare, labor, and transportation, and the development of Brain Science

After World War II, relative morbidity of mental disorders and cerebrovascular diseases began to increase, as that of tuberculosis decreased. In 1955, brain research was pointed out as one of the basic research areas that should be extensively promoted in Japan.

During the 1960s, the threat to health from mental tension, fatigue, maladaptation, and stress associated with rapid social changes and increasing complexity was pointed out.[35] Optimistic expectations on human engineering to provide countermeasures took place at first. Advances in psychiatry and the development of psychotropic drugs raised expectations for the returning of patients to society, and study of home- and community-based mental health care began.

During the years 1970–1975, the morbidity of elderly people raised sharply, with the peak age group rising to age 75–79. After the population of people who would have certain difficulties in living a normal life in 2020, i.e., those who would be elderly, disabled, or caring for them, was estimated, development of welfare equipment was promoted as a means to cope with the advent of the aging society.[36] Furthermore, the past trust in human engineering, in which conditions of patients were simply considered as matter of engineering specifications turned out inadequate. New ideas in engineering able to meet individual needs were sought in order that it can meet requirements of individual humans.[21] There was a change in the way the health of elderly people is viewed as well. Elderly people suffering from dementia came to be treated as suffering from mental disorders rather than simply being dismissed as "senile".[37]

Since the second half of the 1970s, demand for medical rehabilitation has climbed rapidly as workplace and traffic accidents have increased, and the number of people suffering strokes and their aftereffects has risen. The increasing incidence has led to the progress of clinical research on sensorimotor and linguistic functions. In addition, through medico-engineering collaboration, the development of computerized prosthetics, nursing equipment, welfare robots ("guide dog" robots, etc.) and artificial neurons and the preparation of enclosing environments that enable the most effective use of these devices are being promoted.[20, 22]

During the 1990s, increases in depression, death from overwork, and suicide were raised within the focus of public attention. Entering the 2000s, consideration of 'countermeasures against depression as a means to prevent suicide' began. Furthermore, examination in the context of Brain Science of various previously overlooked issues such as those below also began.

- Human factors such as inattention, mistakes, and negligence that cause serious disasters, for example, in aviation and nuclear power plants.
- Measures to support decision-making of responsible persons, rescue staff, and the general public in the event of earthquakes and

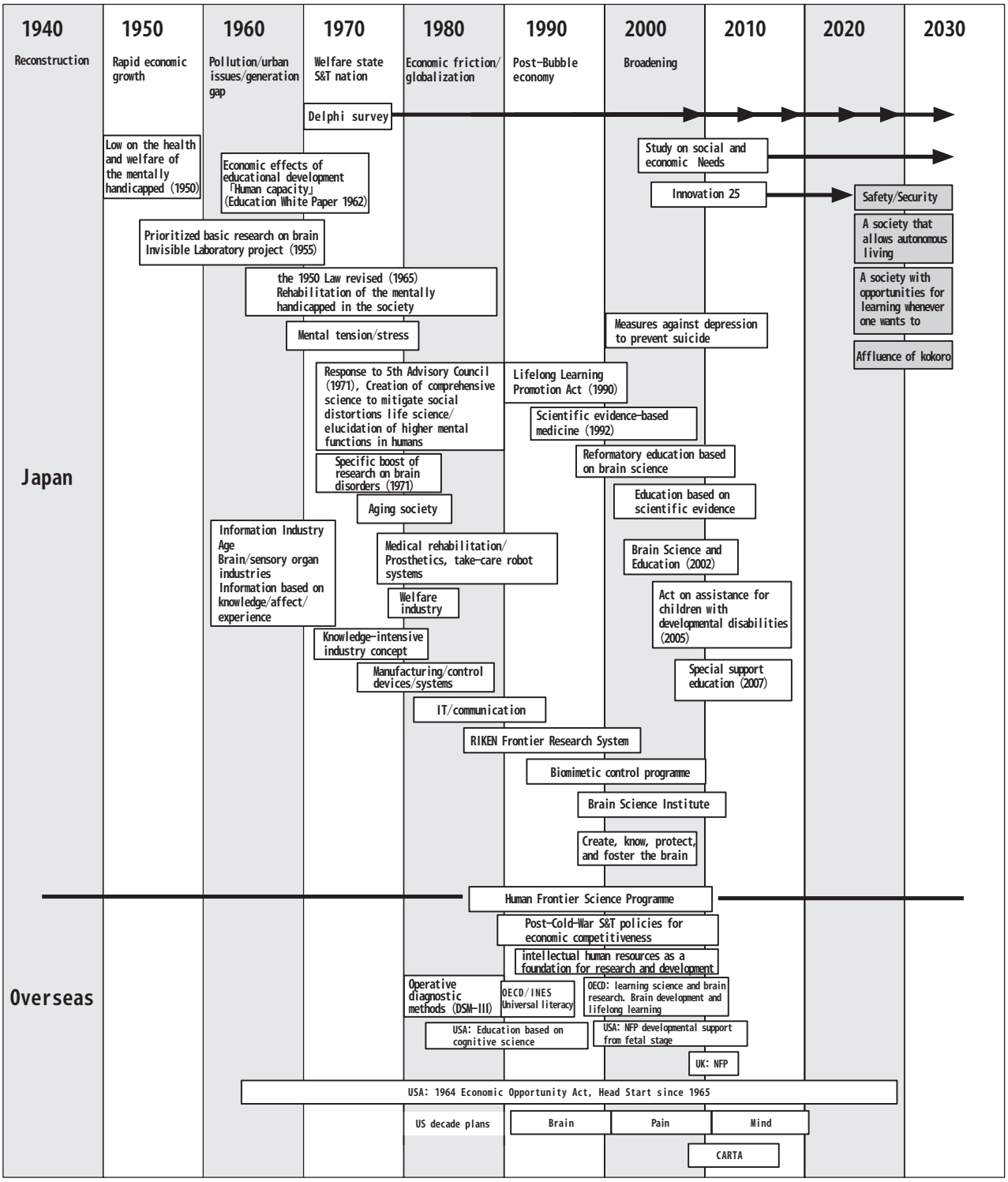

Figure 3 : Postwar policies that influenced today's Brain Science

Prepared by the STFC

Figure 3 depicts the main flow of postwar policies that influenced today's Brain Science. Positions at the left of each box indicate the dates each policy or report was issued. Policies of international organizations and foreign countries are shown in the lower part of the figure.

Characteristics of Japanese policies include the performance of long-term foresight research and the setting of policy goals at an early stage, the continuity of these practices, and efforts to create organic links across disciplines and establish comprehensive science. There are structures that can implement such policies even throughout changes of cabinets. Furthermore, Japan launched an administrative reform to integrate science and technology administration with that for education, culture, and sports ahead of other countries.

other large-scale disasters.

- Effective protocols for effective communication with people with cognitive, perceptual, and/or motor disabilities.

4-2 Brain Science as a contributor to the elimination of social distortions

During the 1960s, various social problems such as pollution, undesired effects of urbanization, the generation gap, and the hollowing out of local communities came to the fore. In its fifth advisory report, "On the Basics of Comprehensive Science and Technology Policy in the 1970s"[38], the Council for Science and Technology Policy asserted that existing science and technologies were inadequate in some ways to eliminate "social distortions." It proposed the creation of a new comprehensive science to solve those issues. Life science, soft science, and environmental science were mentioned as key fields, with support for the humanities and social sciences as well. Items relevant to today's Brain Science were as follows.

Life science

"Information transmission," "memory and learning," "interaction between life and environment," fundamental elucidation of life itself, etc.

Soft science

"Prediction of occurrence of foreseen problems," "consistent and comprehensive planning by systemic elucidation of multiple problems connected deep interrelationships," "improving intellectual potential for creation, judgment, and management in various types of decision-making and research," "science and technology related to behavioral science, social ecology, creation, judgment, cognition, and other intellectual activities," etc.

4-3 The policy to "create the brain"

Creation of systems with functions comparable to life system was proposed as a new approach to biological research in 1960. It was already pointed out that creation of an artificial brain alone is insufficient because an artificial brain would not demonstrate the functions of an entire human being.[39] During the 1980s, some researchers independently began creating intelligent systems or artificial life in a constructivist way. In Japan during the 1990s, numerous researchers from different fields began collaborating for projects with constructivist approaches to create intelligent systems that have bodies and interact with others.[23] In 1997, principles for the promotion of Japanese brain science advocated the concept "create the brain" as well as "understand the brain" and "protect the brain." Elucidating brain functions by creating not just the brain, but also bodies that can implement autonomous movement (robot helicopters, etc.) was an attempt to introduce a constructivist approach in science and technology policy.

The following are part of the characteristics of the "create the brain" concept.

1) Understanding of the brain as nonlinear systems, which are difficult to elucidate with analytic methods. This is an approach to discovering what is sufficient condition to realize equivalent functions as the human brain does, which differs from supposing the necessity of limited components of the brain by destroying or suppressing them.
2) Scientific research on the mechanisms that confer meanings to incoming information and create new meaningful information
3) Availability of descriptions arising from an interior viewpoint of the self rather than those from exterior observers
4) Possibility of validation in real-world: Research to understand intelligence in the complex and unpredictable real world, with simultaneous advancement of research and development that evolves in the real world and has a high likelihood of application there.

The true value of the "create the brains" research can hardly be predicted from the extrapolation of present situations and may only be widely appreciated after several decades or a century. One of the current problems is the fact that appropriate ways for evaluating and promoting the analytic and descriptive research may not necessarily be the best way for constructivist research. Furthermore, certain issues might only be understood by combining the results of both kinds of approaches. It is therefore necessary to recognize the characteristics of each of them and efficiently carry out science and technology policy.

Asking questions such as "Is it possible to create the brain?" and "Why?" or "Why not?" might be good cues to initiate and promote public dialogue.

4-4 Japan's education accentuating こころ (kokoro)

In traditional Japanese education, character-building has been an important object. From the late Edo period, the percentage of children attending clan and private schools has been high, and each child was educated according to her/his potential. By using calligraphy as core of the pedagogic strategy "learning by practice and reading," the integration of the perception, action, conduct and social skills was fostered.[40] The percentage of school attendance was maximized by a compulsory education policy since the Meiji period.[41] A white paper in 1962 reported that the tradition of high school attendance and literacy as one of the foundations for Japan's high economic growth.[42] Even then and after, the idea that the object of education is "character-building" remains accepted widely.

As Brain Science progresses, the brain's diversity draws people's attention in recent years, and education policies put increasing emphasis on attempts to respond to the individual needs of each infant, pupil, or student to learn.[43] Regarding the Special Support Education launched in April 2007, the government stated that "Special Support Education is crucially important not only for the education of pupils/students with disabilities but for building up of symbiotic society where, recognizing the diversity of individuals, everyone can enjoy their activities regardless of difficulties, disability, disorder, or any other differences. This initiative is very meaningful for Japanese society, both today and in the future".[44]

Since the latter half of the 1990s, within the framework of improving reformatory education, Brain Science, such as cognitive science, behavioral science, psychiatry, and developmental psychopathology, has been applied as the base for education and such attempts have been evaluated in actual practices at part of the juvenile correctional institutions under the jurisdiction of the Ministry of Justice. Taking into account minor developmental disabilities, this correctional education is based on lifestyle models that include careful learning plans, dietary therapy and nutrition guidance, physical discipline, fostering of understanding of others and communication skills, improvement of self-esteem, and training in a disciplined life and group activities.[45] The understanding and cooperation of guardians are also sought. Fewer youth come again to similar institutes by repeat offense after having finished their terms at institutions where these attempts are being made.

For Special Support Education and reformatory education, the diversity of the brain and the fostering of children's self-esteem are now emphasized more than raising academic ability. Self-esteem of a child or a youth described here is not exaggerated pride, but rather nature cultivated upon an awareness of one's strong and weak points (meta-cognition), the improvement of learning ability based on awareness, mutual understanding with others, and knowledge of how they accept her/himself. People in general, whether they are children or adults, may have difficulties and weaknesses. It is becoming apparent that measures to compensate for such difficulties have not been adequately implemented.

4-5 Trends in Brain Science in the world

During economic friction with other industrialized countries in the 1980s, Japan began to globalize its research and development activities. The Human Frontier Science Program launched in 1989 by Japan's initiative promoted international collaboration on brain science from the beginning. In the 1970s in the field of developmental psychology, increasing numbers of observations of babies suggested their richesse of abilities immediately after birth. An international survey supported by the Human Frontier Science Program has testified that this is a biological entity that transcends differences in culture or geography.

After the end of the Cold War, many countries reoriented to economic competition based on science and technologies rather than a military one and began turning their attention to mechanisms that the knowledge, on which science and technology stand upon, is created. Furthermore, countries also began considering people involved in research and development or with high skills as resources and began seeking greater efficiency not just in higher education but also in primary or nursery education in order to strengthen the

national level of intelligence and skills. During the 1980s, the OECD began conducting fact-finding surveys and disseminating knowledge regarding universal literacy and "brain science and education."

The USA began the Head Start early education program based on the 1964 Economic Opportunity Act in order to enable children from culturally and economically deprived families to get off to a good start in school.[46–47] Since the issuing of the 1983 report "A Nation at Risk," the USA has promoted education based on cognitive science.[5] In the UK, although childhood education was traditionally considered a family matter, since the administrative reforms under Prime Minister Brown, the Department for Children, Schools and Families (DCSF; the equivalent of a new Education Ministry) began addressing childrearing, including childcare and family support. The government supports families and environments for newborns from the prenatal stage. Both the UK and the USA are examining early intervention to prevent antisocial behavior, delinquency, and crime, tending to consider those phenomena from the perspective of brain/neuroscience and developmental psychopathology.

For promotion of brain science research, the United States Congress passed a resolution setting the policy of the "Decade of the Brain" from 1991 to 2000. In 2000, Congress designated the "Decade of Pain" (2001-2010)[48], and a possibility of the "Decade of the Mind" as the following decade is now being discussed among academic communities in the main, government agencies and general public.[18] Concerning pain, high correlation between stimulus and evoked response is seen at the receptor level. Due to cerebral nonlinearity, however, it is not the case in higher order, and the only person who is feeling pain can tell what kind of pain it is, how much it hurts, and how difficult it is to endure. As seen in the theme from "Brain," "Pain" to "Mind," the US Decades are focusing on an increasingly abstract objective. A campaign to define and understand pain is also taking place

Table 1 : Changing approaches in psychiatry

Period	Psychiatry		
1800s	Emotions and understanding directly affected by sensory impressions are etiological locus of mental disorders.		
	Biological psychiatric medicine	Boundary area	Psychopathology
1850s	"Mental illness is cerebral illness" Physical disorders Methodologies of Natural science		Holistic understanding Physical findings alone cannot explain the specificity of experience and behavior, the mind, subject, intuition, self, others, situations
1930s	Shock therapy		
1950s	Pharmacotherapy		Social communication, family therapy of the Palo Alto school (Batson)
1960s			Premorbid personality theory
1980s	Operative diagnostic standards, DSM-III	Twin study epigenetic puzzle	
1990s	Identification of genes related to mental illness Analysis of epigenetic and genetic characteristics		
2000s	Polymorphism Behavioral genetics	“intermediate phenotype”	"Depression-related genes" may be related to the premorbid personality rather than disease itself.

Prepared by the STFC based on References[51-53]

Even biological psychiatry has begun to consider differences in race and region and to postulate intermediary characteristics for so-called depression related genes, moving closer to psychopathology and the theory of premorbid character. The possibility for cooperative development of biological research, such as behavioral genetics, and psychopathology is increasingly expected.

in Europe through the International Association for the Study of Pain (IASP). In Germany, interdisciplinary research and the establishment of a clinical system are being actively pursued.[49] In Japan, although outstanding research at the molecular level is underway, there has been no promotion of interdisciplinary research on pain at the system, cognition, or behavior levels. Little attention has been paid to the "Decade of Pain" movements.[50]

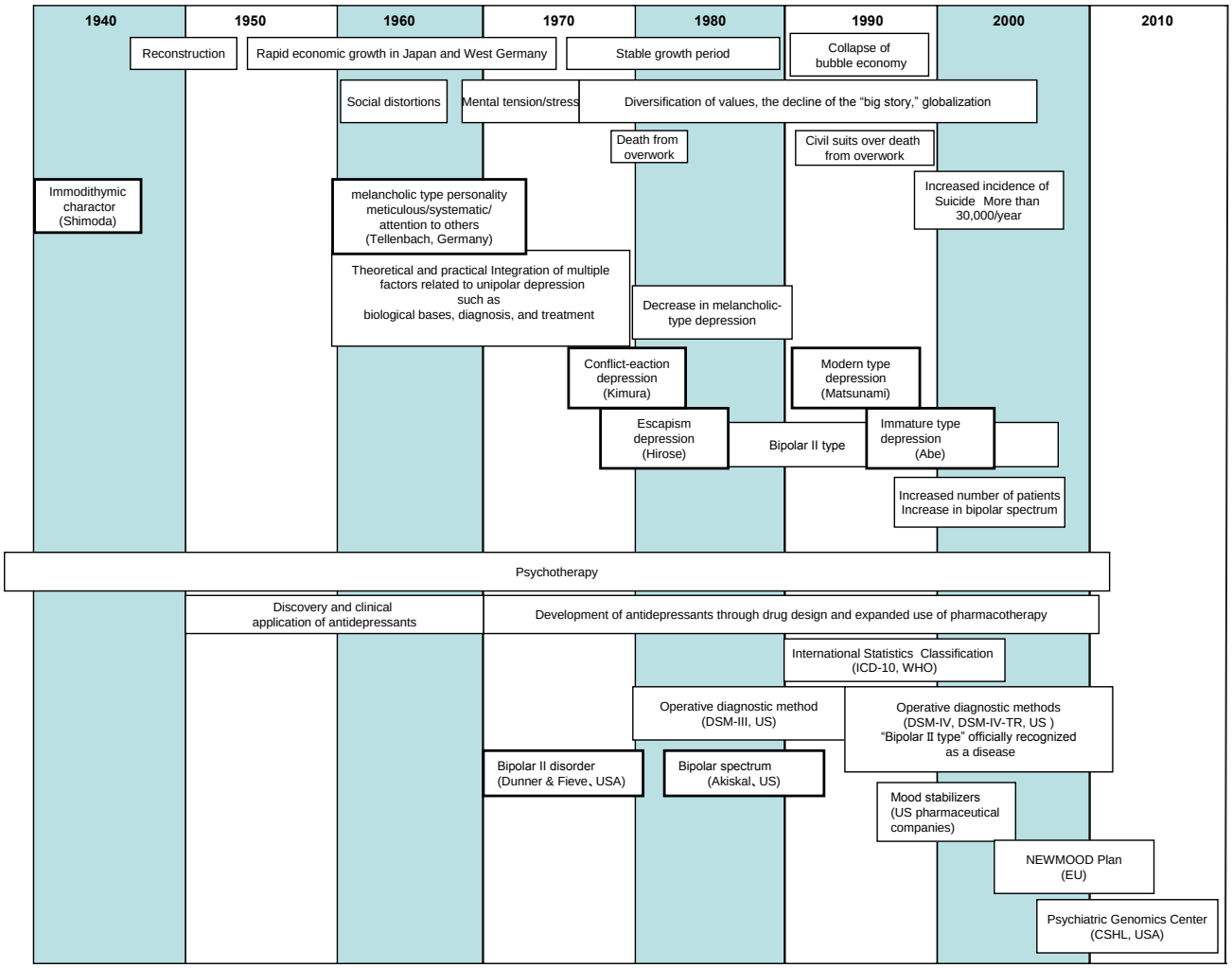

Figure 4 : Changes in mood (affective) disorders

Prepared by the STFC based on Reference[52]

The broad frames show major types of mood (affective) disorders (depression, bipolar disorder), which vary depending on geography and the times. The left of the box indicates the time when the terms, concepts, or incidence first appeared. In Japan and West Germany during the recovery and rapid economic growth after World War II, the most typical mental illness was the depression seen in melancholic type people who were earnest, had a strong sense of devotion and belonged to organizations, however, they are without a "story after achieving goals." This type of depression tended to decrease with the end of high economic growth. On the other hand, during the era of economic stability and after the bubble economy collapsed, categories of depression diversified, including bipolar disorders with a manic state, and the number of patients increased. The annual incidence of suicides, which correlates with the number of mood (affective) disorder patients, recently kept at the same level of approximately 30,000. From the 1990s, the increasing number of court cases between the bereaved of workers who committed suicide and their companies that were stuck on whether or not overwork caused depression and suicide.

5 An example of Brain Science promotion: Psychiatry

Psychiatric disorders change along with the times and society. Pathology changes above all. This cannot be explained by the classical genetics, and psychiatric disorders cannot be elucidated with genetic science alone.

Furthermore, what people consider normal or abnormal and how individuals with unusual aspects are accepted or excluded by their families or societies also change along with the times and society. The way others regard and are in contact with patients affects the way they regard themselves and changes their clinical condition. Psychiatry is therefore an area where understanding of interactions among the self, others, the environment, and society manifests as an important element.

Within the psychiatry, psychopathology is a study aimed at understanding the specific nature of a person's experiences and behavior, which can hardly be defined in terms of physiochemical data, and providing treatment accordingly. (See Table 1.) In Japan, a clinical system based on Japanese characteristics and the traditional psychopathology is still practiced, in which doctors and patients develop very careful relationships. It would be important to design research so that it uses a psychopathological framework and utilizes the expertise and tacit knowledge of doctors to link micro-level and macro-level knowledge that would be important.

On the other hand, biological psychiatry has been working to elucidate disorders of the biological brain using natural science methods since Griesinger asserted "Mental illness is cerebral illness" in the mid-19th century. Pharmacological approaches have been increasing their importance since the 1950s. In recent years, vigorous research to identify responsible genes and genetic polymorphism are being made. The Diagnostic and Statistical Manual of Mental Disorders in the USA has employed an operational diagnostic method since the third edition in 1980 (DSM-III). This has advantaged biological psychiatry and psychiatric genomics, promoting biological research and the application of its results. Japan's Health, (Labor) and Welfare Ministry has used the World Health Organization's ICD-10 in its statistics since 1990. The DSM-III, -IV, and -IV-TR also have a significant impact on clinical practice. (See Figure 4.) Overdependence on operational diagnosis may lead to missing subtle symptoms, jeopardizing trust between doctor and patient, which is indispensable in psychiatry.

5-1 Construction of society with less depression and suicide

The symptoms and frequency of depression are significantly influenced by individual personality and character, physical factors, interaction with others and with society, and the geographical, historical and cultural background of society. In Japan, the number of sufferers and the types of depression and other mood (affective) disorders changed rapidly synchronously with the rapid social changes that followed World War II in addition to social characteristics and personal character traditionally recognized in some people. There is a clear correlation between mood (affective) disorders such as depression and the number of suicides. Annual incidence of suicides has kept at the same level at approximately 30,000 since the end of the 1990s.

In order to study mental states of patients, which can alter every moment, it is inevitable to use methodology based on psychopathology and nonlinear dynamics. Even if research at the molecular level claims to identify ‘depression-related molecules’ and their regulatory mechanisms, such information must be connected further to the macro-level phenomena of the individual, family, and society for actual prevention and treatment.

Style of cognition may alter physical conditions (the brain and genes) in the long term. It is therefore quite important that clinicians and researchers in biological psychiatry and psychopathology closely collaborate.

5-2 Adoption of virtual reality (VR) systems

Virtual reality is an effective means to reproduce, analyze, intervene in, or change situations where individuals, others and their environment interact with each other. Use of virtual reality in psychotherapy was proposed in 1993. Today it is used to treat phobias and eating disorders in

Europe and the USA.[26–27] If a sense of immersion is sufficiently accepted as beneficial for humans, large-scale equipment is not necessarily required. For example, when patients arrived at the stage where they can use the equipment by themselves equipment that can be used in everyday living environments, such as HMDs (head-mounted displays) and PDAs, is expected to produce greater therapeutic results. In recent years, most VR systems can be sufficiently operated with ordinary personal computers. The emphasis of research and development has shifted to software, setting of cognitive and psychological contexts, and total framework.

In Japan, VR researchers have tended to focus on the development of large-scale equipment by accumulating state-of-art technologies. Furthermore, VR that focused on environmental settings seemed to have little relevance to brain science. However, because Brain Science has come to treat the environment as an inseparable entity from human cognition, VR is going to be studied within the framework of Brain Science. It is also expected that new VRs will be applicable in medical care and education by utilizing the knowledge, hypotheses, and methods of Brain Science.

Psychopathology addresses disorders that emerge through interactions of individuals with others and their environments and that cannot be thoroughly explained by genetics or pharmacology. In many cases, the clinical condition is inconsistent and the patients weaver between normal and pathological states. VR might be quite effective to elucidate the mechanism of this mental perturbation. Schizophrenia, depression, and bipolar disorders might be particularly suitable for research using VR. Tackling these issues would also provide a good opportunity to enhance software development and cognitive and psychological approaches in the research and development field of VR. Furthermore, activities of Japanese VR researchers often overlap those of robotics researchers. The field of robotics has already achieved mutual penetration with brain/neuroscience and cognitive science. Proceeding with research and development of systems integrating VR and robotics would be useful.

6 Future Issues

6-1 Innovation from the perspective of Brain Science

The development of Brain Science has driven people to the point where the possibility to change authentic human psycho-neuro activity itself is discussed, even if the goal is not necessarily the treatment of disease. Here it is important to consider seriously what is the exact subject to be changed and what is "the natural state of human beings" in the first place. The present state of human beings is already a mixture of biological predisposition and accumulated artificial changes through social lives, knowledge and technology. Keeping this in mind, if one were to attempt to set criterion of the "natural state of humans," there would be no universal answer. Each community would need to discuss the question by itself based on its geographical, historical and cultural backgrounds and make its own decisions. First, in order to do so, profound understanding of human evolution from the viewpoint of Brain Science is indispensable.

(1) External memory

In recent years, 'external memory' or 'external brain' is metaphorically discussed in information technology. From the perspective of cognitive archeology, however, humans have been producing external memory for at least 50,000 years.[17] It is supposed that these phenomena were caused by the fact that the quantity of information humans dealt with had increased. The next issues are reasons that the amount of information increased, why humans increased the information they dealt with, and what caused its motivation.

(2) Desire for innovation

Some researchers in Brain Science and artificial life assert that human brains are structured with an inevitable desire for innovation.[1, 2, 7, 28, 30] Other organisms also happen to use and modify their environments to match their cognitive patterns and to adapt themselves to their environments by forming new cognitive patterns.[54] Humans, however, have a positive feedback cycle of "obtaining information,

developing technology thanks to the information, improving their environment, obtaining better and more information, and developing better technology using the latest information." By bringing the natural environment under control and by ameliorating maintenance technologies of information, humans are about to escape from negative feedback and effectively shift into a monopoly of positive feedback.[2] In order to control the desire for innovation, humans must elucidate mechanisms of positive feedback.

(3) Mechanisms of human desire

Approximately 30 years ago, engineers began to tackle new issues such as how to incorporate the structure of human desire into engineering. The belief was that "Invention was the mother of necessity" for a long time rather than "Necessity being the mother of invention" (KAWADA Junzo). As environmental and social problems surfaced, and the preservation of the global environment and ecosystems and the limits of natural resources were recognized, science and technology policy turned to put its priority to meeting social needs. In order to preserve the global environment and ecosystems, it is indispensable to understand the structure of human desire. The most plausible constraint for controlling the inevitable positive feedback of human brains would be, in turn, the necessity of preserving the global environment and ecosystems. New engineering and industries are necessary to reorient "the human desire for innovation" toward positive feedback for spiritual exploration from positive feedback based on consumption of energy and materials.

6-2 Long-term longitudinal (cohort) studies

Long-term longitudinal studies are important for studying the mechanisms by which personalities are built, and developmental disorders or mental illnesses manifest. The national government should take the lead in promoting such research.

When a human lifetime is overlooked, drastic integration and disintegration of various neural and physical systems take place especially during the fetal, newborn, and adolescent stages. A part of psycho-neuro disorders previously thought to be "innate" have only a low degree of penetration of genetic factors. Whether their phenotype manifest or not may therefore depend on the process of integration or reintegration of neural and physical systems. If research focusing on developmental periods as described in section 3-3 brings about novel methods to detect and intervene developmental process of disorders antecedently, they may result in the prevention of pathogenesis in children with genetic risk factors. Furthermore, minor developmental disorders due to neurological causes do not have a distinct border with brain diversity and personality. Rather than simply aiming to "cure disorders," while considering that today's childrearing, education, and social systems are not necessarily optimized for human brain function, it is important to design research and development so that those systems can be improved.

It is therefore necessary to use long-term longitudinal studies beginning at the fetal and infancy stages to research not just the brain and nervous system, but also correlations among various elements, including social and environmental factors such as family and community. Because it is impossible to address every issue in education and healthcare from the beginning, it would be effective to narrow down subjects and begin with core subjects that can expand into a variety of themes in the future. Possible topics for initial study include the following.

- Nonlinguistic logic and memory and gestalt perception: Potential elucidation of the mechanism by which people obtain, with the actual feeling of 'understanding,' concrete knowledge grounded in one's own memory, experience, and embodiment
- Development of individual modular perception and associative perception based on them: Potential elucidation of the development of reading, writing, and calculation abilities and their perturbation
- Analysis of the development of "theory of mind" and social conduct ability
- Analysis of the common points and differences of homozygote twins: Their differences in particular can contribute the analysis of psycho-neuro traits that emerge through interactions between the individual, others, and the environment rather than caused by genetic factors. First, research combining dynamic

analysis of the development of movement and perception with analysis of stress and depression in children would be significant.

Researchers participating in long-term longitudinal studies dedicate themselves to the research for a long time, and it may be difficult for them to publish articles while the research is underway. It is necessary to provide a protection and support system for researchers during longitudinal studies and for continuation of their careers after completion of their research.

When the government implements a long-term longitudinal study, it must explain any disadvantages or advantages associated with participation. Studies should be designed and operated so that subjects benefit over the long term through an increased level of awareness by participation.

First, it is important to promote careful and strict research in special research zones that take into account the geography and culture of the local communities. Once this gives favorable results, strictness of research conditions may be lowered to encourage the public to participate nationwide.

Nationwide longitudinal Brain Science studies in Japan have the following advantages.

Japan's advantages

- Japan is a relatively large linguistic area (9th in the world for a population using Japanese as mother tongue and 11th for a population using the language as official language, according to the Cambridge Fact Finder 1993).
- Japan has a relatively closed geographic environment.
- It has had a high literacy rate since the Edo period and people have had strong intellectual inquisitiveness.
- The Japanese people retain hunter-gatherer views of the world such as nature worship, ancestor worship and animism, in parallel with their successful modernization.[5]
- Japanese people have strong propensities to surmise others' feelings and to modify their own comportment accordingly. Cognitive psychology tests produce different results than when given to Americans or Europeans.[55–57]
- In psychiatry, Japan retains a therapeutic system based on psychopathology in which medical doctors and patients have careful relationships.
- Japan belongs to the kanji culture sphere, which differs from Indo-European linguistic sphere. It is advantageous to carry out the linguistic research in situ and research on the expression and transmission of abstract concepts using integration of visual images and physical perceptions (e.g., calligraphy, SHIRAKAWA's kanji studies, and measures against reading/writing problems) are easy to perform.
- Japan has no significant ideological conflicts over Brain Science or the theory of evolution.

In order to promote Brain Science based on social needs under the social situation such that information is excessive, changes are rapid, and needs are diversifying, it is necessary to continuously collect large amounts of information. It is necessary to construct a system in which most of the public can voluntarily participate, release useful data, and utilize shared information. This could be the beginning of the construction of an information transmission and co-utilization system with a reliable foundation in science and technology.

6-3 Spiritual affluence and Brain Science

What does Brain Science today tell about pursuing or feeling affluence of the *kokoro*? The brain is not "the *kokoro*" itself, so it is quite unlike that a locus of "the *kokoro*" is found somewhere in the brain or that the state of "affluence of the *kokoro*" can be reduced to certain brain activities. This does not mean, however, that "affluence of the *kokoro*" is something that exists externally and is to be pursued there. Instead, some argue that the kokoro emerges at an "interface" where elements such as body and brain, self and others, and self and the environment interact. The brain should be related to this interface of emergence.

The first approach could be an investigation of the way in which "affluence of the *kokoro*" forms. Even when people completely forget what they heard, saw, felt, or said when experiencing music, travel, conversation, and so on, they often remember just that they enjoyed it. In such cases, meaning may have been created and transmitted through the structure of the interaction itself rather

than through its content. A typical example is the relationship between a baby and its caregiver. Babies do not understand what the caregiver says to them or the meaning of a smile. Because exchanges with the caregivers are positively felt, babies repeat the action and are gradually entrained into the caregivers' language games.

For music, research based on the premise that both novelty (deviation from expectations) and familiarity (conformity to expectations) are necessary, and that the fluctuation (timing and balance) between these factors make the listeners feel agreeable. Taking schizophrenia's suffering into account the formation of "affluence of the *kokoro*" may require confidence as if the self does not fluctuate even when one is actually entrained into fluctuating relationships. To be good musicians and interlocutors, a "theory of mind" is required. They do not merely transmit segments of music or language (predictability); they play or talk by anticipating "how the listener will interpret what I give them" and "what the listener will think about it" (deviation from predictability). It is becoming clear that fluent conversation requires proper turning of one's own gaze and literacy of interlocutors' gazes.[13] Some of the common language confusions found in people with autism are also seen in children who are born blind.[30]

What brings individuals a feeling of "affluence of the *kokoro*"? Comprehensive advancement of basic research from perspectives such as psychophysics, complexity, "theory of mind" research, psychiatry, and the humanities and social sciences will be useful. One approach to seeking affluence of *kokoro* could be the elucidation of the causes of schizophrenia and depression, whose sufferers are unable to pursue or feel the affluence of *kokoro*, and the reduction of those causes in society to the extent possible.

6-4 Research in the humanities and social sciences

Emphasis is shifting from the perspective that there is an objective external world and that knowledge consists of accurately knowing that world to the view that knowledge is created, that there are many valid forms of knowledge depending on observer, subject, and situation. In the world of science and technology, the methodology of invention and discovery itself became a topic of study during the 19th century. During the 20th century, language to express knowledge itself became a research subject (Russell, Wittgenstein, etc.). In the 21st century, the creation of thought and knowledge, "understanding" itself, become a subject to be studied. The notion that knowledge is "created" is growing in importance. The school of thought prevailing since Descartes and Bacon, the idea that there is a universal, objective, external world, and that reliable knowledge can be obtained through validation methodology based on materialism and reproducibility, made a significant contribution to science and technology in the 19th and 20th centuries. On the other hand, different schools of thought such as those of G. B. Vigo, TOMINAGA Nakamoto, C. H. Pierce, and G. Batson were studied in the humanities and social sciences. In Brain Science during the 21st century and thereafter, it is useful to put such research forward.

It was suggested scientifically by Brain Science that awareness of the "self" might be constructed and maintained through interaction with others and with communities. In addition, some Japanese researchers are reconsidering the notion of the individual that may have been overemphasized in the modern Western view of the self that was adopted in Japan during the Meiji period. Reviews of the history of the concept of the ego since the late Edo/early Meiji period have been performed in the fields of literature and psychopathology (pathography). These should be further pursued as part of Brain Science. Present brain/neuroscience has not yet developed a mature description of the self.

The cognitive patterns of humans today are constructed through a mixture of biological and cultural/social factors. Because cultural/sociological changes have been especially significant since humans began agriculture and livestock breeding approximately 10,000 years ago, the contributions of anthropology, history, and social science are important when the findings of Brain Science are applied to the actual world.

Databases of Japanese literature in the humanities and social sciences (e.g., articles in specialty journals, books, lecture records, anthologies, and digital media) should therefore be constructed and

maintained so that both experts and the public can use them. Databases with identifiable authors should be kept upgraded.[58]

6-5 Other relevant areas

Relevant area	Characteristics
Open platforms for understanding human behavior	The Digital Human Research Center's Open Life: Models of broad human cognitive behaviors are proposed by using, for example, Bayesian methods to analyze human subjectivity by applying elements usually considered difficult to use in statistical analysis. For example, children's body images and cognitive patterns have been surmised from adult perspectives before, but this platform can provide cognitive and behavioral models from the viewpoints of children at various developmental stages by taking the observations and insights of doctors and psychologists into account. It may also be used to develop accident prevention programs for children.[59]
Open software platforms for analysis of human behavior	The Research Group for Sociointelligenesis has already developed cognitive developmental robotics. Now, based on the National Institute of Informatics (NII), a software platform enabling participation by a broad range of users and long-term test series is being developed. The goal is to enable simulations that integrate perception, dynamics, and conversational behavior to allow various agents such as robots, virtual agents, and users (humans) to act in complex environments. NII is constructing multiple databases covering not only natural science but also the humanities and social sciences. Promoting effective integration of these elements would be significant.[58]
Ontology (philosophy and information science)	Terminology, knowledge, and concept from multiple areas are linked while preserving the descriptions of different knowledge systems in order to maintain the detailed implications of statements in each area comprising Brain Science.
Semantic editors	Based on the criterion that "if something is written so that a machine can understand it, then non-specialist humans can understand it as well," it is intended to allow non-experts in a specialized field to understand research results of the field by providing a standardized abstract of publications such as papers, books, lecture records, anthologies, bulletins, digital media, etc.
Use of information media for open peer review	Opportunities to present research based on visions, hypotheses, and embryonic ideas

7 Conclusion

Sustainable "maturity"

One issue that arose during the 1960s was social distortions due to "accelerated change." From a Brain Science perspective, a particular characteristic of the human brain is its irresistible propensity for innovation. When innovation itself becomes the focus of interest, exponential social change may take place. In the future, the creation of new policies to control the desire for innovation may become indispensable to maintain society, the global environment, and living systems.

UMESAO likened change in the 19th and 20th centuries to the growth of muscle and bone. It is becoming universally obvious that the system that longed solely for growth through the industrialization of materials and energy is reaching its limits. Human beings must turn their irresistible desire for innovation inwards to develop spiritual industries and aim for maturity. Rather than worrying about the growth of just industrializing countries, Japan may be at the stage where it should dedicate itself to achieving maturity.

Today, it is necessary to reconsider issues that have remained unsolved since the 1960s and 1970s and seek solutions for problems that have grown more complex as well as new problems. It would also be meaningful to advance Brain Science from the perspective of elucidating life systems and maintaining ecosystems.

If human cognition patterns change through interaction with the environment, it would be possible to consider that human beings are still evolving, and even if it is unable to completely control the process, it may be possible to design evolution to orient to desirable directions. If humans have not yet evolved control functions for new abilities they had acquired, they must create internal mechanisms to control the positive feedback loop of information acquisition and its control. During discussion of "Innovation 25," some participants held that while technologies rapidly rise and fall and are therefore difficult to foresee the future based on them, fundamental human demands alter relatively little, so it is more reliable to foresee the future based on demands. Rather than enhancing human abilities or tolerance from the outside with novel technologies, machines, and medicines that appear available immediately, it would be better to improve the internal personality and social systems by pondering what kind of existence we long to be and what kind of world we wish to live in. It is quite important to manage Brain Science *lato sensu* to contribute to this process.

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2

Technical Trends and Challenges of Software Testing

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1 Introduction

Software tests are (herein referred to as software testing) commonly known as "a test to verify if there is no problem with software". Software testing, in this sense, may seem to be similar to tests of various "artifacts (products)" such as ones to check the safety of confectioneries, whether batteries are produced as specified, or whether an aircraft has any problems concerning its flight. In fact, many problems have been revealed concerning inspections and testing of these products in recent years.

On the other hand, unlike such tangible products, software would have different types of problems because problems in software are hard to see by users until such problems actually are visualized by a series of defects. In the case of tangible products, you may notice some indication before the serious problem occurs. In other words, unless the certain conditions are tested for the defects, the software is considered and treated to be at normal state, or "no problem". In a more extreme statement, it can be said that problems attributed to software are caused by insufficiency of its testing.

Recent software related problems are largely caused by lack of testing, and have actually brought social problems and financial losses. For example, there was a failure with the New Derivation Trading System, which deals with derivative products, of Tokyo Stock Exchange on February 8, 2008. Due to this problem, the trading system operation have been suspended until the 12th of the month. The reported reason of the failure was an "initialization error with the memory within the server, and no initialization were conducted under a certain condition".[1] While this system was originally planned to be in effect from October 2007, testing showed that there were numerous problems. Therefore, the operation of the system was delayed for 3 months, and it started to be in use from January 15, 2008. The Tokyo Stock Exchange also had an accident in November 2005, in which their system failed and all stock exchanges were suspended.

In 2007, there was also an inconvenience with the automatic gate system at train stations in and around the Tokyo metropolis. There have been many reports and opinions on this issue.[2-5] For example, a TV program reported that it was caused by a comparatively simple error ("+offset" was missing). In this case, the bug was not noticed until a certain condition is met. Once this condition occurred, it caused errors to all connected automatic gate machines. In addition, as this error affected the entire rail industry of the metropolis area, it was reported as a significant social problem with several million people suffered. Such events should not happen if some test were conducted to check these specific conditions of this accident. It was told that only such limited number of tests were conducted for big numbers as 1000, 5000 and 10000, so they missed the special case relating to the buffer which caused failures.

Due to the increasing complexity and proliferation of software, the importance of tests is increasing. However, the difficulties of testing are also increasing. There have been various attempts to solve these software testing problems. Recent trends in software testing have been frequently reported in technical community.[6] For instance, a group for testing security software products named Anti-Malware Testing Standards Organization (AMTSO) was formed on February 5, 2008. As malware has become more diverse and products

has become more complex, the appropriate evaluation of the tests for current security software had become difficult. This organization is to improve testing methods and appeal the practical standards and guidelines to the world.

In this report, first, the meaning of software testing will be made clearer, especially for the so-called "embedded systems", so that the testing becomes important for the technology related to the safety and security of citizens. Next, the testing technologies are sketched, and the emergence of companies and organizations specialized in software testing is reported. As the biggest issue of software testing, this paper reports the current treatments of software test designers and engineers, as well as the current state of their education. The development of a quality assurance industry based on software testing technology is discussed along with the evaluation of software quality and social/legal systems for software quality. We also need innovations to make all of these issues more commonly understood by general public. This paper summarizes that the efforts to overcome such challenges would contribute to create a "quality" industry in a long run.

2 Tests in over-all software development processes– differentiation from debugging –

In traditional software engineering, software testing was not emphasized much, compared to other parts, partly because people did not recognize the differences between software testing and program debugging as described below.

Software program failures itself may have been seen even in the early days of programming. Efforts to eliminate failures are called debugging since such failures in programs are called bugs. While software tests are related to debugging, they should be considered as a separate task from debugging. This idea was also emphasized in the "Art of Software Testing" by Myers (published in 1979), which is said to be the classic book on software testing.[7]

The differences between debugging and software testing may be summarized as shown in Table 1. Although both debugging and testing have the common goal of quality advancement, debugging aims to eliminate bugs of programs while testing is to identify any defects in the whole program including the system aspects where programs are used. Therefore, it should be noted that these two tasks are completely different in nature.

For example, even if there are no bugs in a program, defects may be found by testing. In other words, debugging is to identify whether a program satisfies the predetermined specifications, while testing is to identify any inconvenience for users of the program.

Here is an example outside areas from software. Suppose some users may put "waterproof" products into the ocean or bath with some chemicals put as bath agents. In these situations, the product needs to not only be waterproof against regular water, but also to have certain durability against salt or other chemicals. It is hardly said to be "waterproof" from the users' viewpoint, that only the regular water is permitted.

Defects identified by debugging are attributed to cases that logic of an intended program was not achieved with the actual program, or there are mistakes in contents. On the other hand, system failures to be identified by software testing are inconvenience or risk for users so that the software should be designed and made to prevent such problems.

Buggy programs are written by the lack of skills of the programmer, and the improving individual programming skills is the responsibility of the programmer. If software testing were considered to be a process for debugging, programmers must be in charge of software testing, which is not a good practice. Putting programmers for testing may eventually lead to a higher risk of overseeing bugs undetected.

As an empirical rule in software engineering, there should be at least some bugs unfound for years in large programs with over ten-thousand lines. Even new bugs (sometimes even crucial ones) could be introduced during the program upgrading (or debugging) tasks. In lengthy and large-scale programs, it is important to conduct software testing from the viewpoint of fail-safe, that is to prevent the system from being damaged significantly or critically even though some bugs are remained and they are hit to do critically damaging function.

Table 1 : Difference of debugging and software test

	Debugging	Testing
Purpose	Eliminate bugs	Evaluate quality risks and guarantee an expected quality
Subject	Program	System (including software)
Work	Correct faults	Identify faults
Worker	Programmer	Test engineer
Start	After writing a program	A test plan is created from the phase of requirements specifications
End	(None = eternity)	Judgment of the person in charge of testing

Prepared by the STFC

3 Definition and contents of current software testing

There are still confusions in definitions of software testing. According to [8], software testing is commonly known as a test to evaluate and then guarantee the level of quality of software, or to verify if there are no risks. With this definition, software testing needs to be started from the upstream operations of software development.

According to the standard which stipulates the life cycle of software, JIS X 0160:1996(software lifecycle process), the test is broken down into the 3 phases.[9]

[1] System and software qualification confirmation tests for the development process.
[2] Operation tests for the operation process
[3] Quality assurance process, verification process and validation process that include testing as part of the lifecycle supporting processes.

In addition, the standard for system lifecycles, JIS X 0170, which includes not only software but also hardware systems, addresses a task called software testing in the processes of verification and validation.[10]

As stated in the Science and Technology Trends No.11, April 2004 "Toward the Improvement of Quality and Reliability in Information System Construction− A Study of "Business Rules" and Requirements Engineering in the Upstream Process",[11] quality assurance activities are imperative in the upstream process to enhance quality and reliability of a system, or in the "super upstream operations", coined by the Software Engineering Center (SEC) of the Information Processing Association (IPA), Japan. It is necessary to investigate the testability from the upstream operations of requirements specifications, not only to check if the users' needs are met, but also to see how the tests will be effectively done. In other words, the quality assurance process should start from the point in the upstream process where demands and requirements are studied, where the person in charge of the test must participate from the start.

Moreover, as introduced in the Science and Technology Trends 2004 September "The Two Rationalities and Japan's Software Engineering",[13] the methodology, known as Agile Development, of making a test program as the first step in program creation, has been promoted a new way of program development. Kent Beck, one of the advocates of Agile Development, has proposed a system called Test Driven Development (TDD), in which the software development itself is constructed around the testing.[14] Furthermore, Hayashi and others have proposed a system where TDD is employed at the modeling stage before the actual program development.[15]

Some says that the software testing process would be unnecessary if it is possible to create high-quality bug-free software. However, if user "demand" is taken into consideration in the first place, these demands will change depending on the time and environment. Therefore, it is important to understand that there is no such thing as "with absolutely no faults".[11] Secondly as history and experiences tell, it is very difficult to design and implement software with no faults or hidden bugs, even if the best developers/designers/programmers are gathered for the process. Consequently, it must

be understood that testing is an inevitable process.

Furthermore, software testing defined as a process of quality assurance or verification of risk-free quality is different from debugging so that it does not expect a perfect program without any failures of components. Rather, software testing should be effective to prevent critical damages on the whole system for users, by taking into consideration of potential failures of the program and its environments.

4 Importance of software tests for embedded system software

In particular, importance of software test is currently recognized in an area called embedded systems or embedded software. In this area, the users have no sense of using software, which is quite different from such areas of personal computer OS and word processors. Embedded software is embedded in a mechanical system, where the software supports the mechanical function.

In the past when computers were not easily affordable, embedded software system was only used for very special systems such as APOLLO aerospace ship or nuclear reactor control. However, with the decline of prices of computers and proliferation of microprocessors, the trend has changed to use the microprocessors for various machines, which also expanded the areas of embedded software usages. Currently, such embedded software would be used in most of mechanical products. For instance, an automobile has some dozens of microprocessors, and the total number of programs of its embedded software exceeds 10 million lines.[16-18] Embedded systems are widely proliferated in a rapid pace. Its business scale in Japan reached 62 trillion yen, or 12% of the gross national products.[19] According to this METI report, the number of employees of embedded system companies are more than 4.71 million, which accounts for 9% of the total workers in Japan.

The business scale is something, but the implication for the quality of the product is more important which greatly affect the quality of life of general public. From this viewpoint, embedded system software currently gains a lot of attention. Any failure of embedded software could lead a significant problem on users, as stated in the example of automatic ticket gate machine failure which was far more than expected by the responsible parties. Failures of mobile phones would require a tremendous amount of costs for recall and replacement of defect products. Embedded software testing becomes more important than that of enterprise information system. Some companies have emerged with the expertise of embedded software testing and are increasing their sales.

The designer of embedded systems should have expertise of both hardware and software. Failures of the system may be caused by both hardware and software so that it is necessary to test both, not either one.

The popularization of Internet and integration of various corporate information systems have a dangerous implication that even conventional information systems to affect various aspects in our society. In other words, corporate systems come to be treated as important as embedded systems for general public. Even one system failure of a company could lead a serious inconvenience to our society. An example is software viruses. There is a possibility that all people are affected severely by destructive viruses with the failure that an individual or a company fails to take anti-virus measures.

5 Recent trend of software test technologies

There are various types of software tests available thanks to the accumulation of its research and development activities. These are categorized depending on testing environment, testing objectives and purposes, testing methods, and the means of testing. Nomenclatures and definitions for the testing types may slightly vary in the textbooks listed in Reference.[20-22] Readers can consult software test technologies and methods described in these textbooks and references. This report describes recent topics.

5-1 Links between test process and software development process

Traditionally, software testing are considered to

be a V-shaped model as shown in Figure 1, because the test is conducted after software development. Consequently, failures are detected and corrected only after software development. Therefore, defects in the upper stream cannot be remedied until the end point of testing, which led an increase of workload for correction.

In the testing phase, traditional focus have been the increase of numbers of tests, which may not bring effective results to solve problems in software. One of the software testing methods developed in Japan is HAYST Method.[23] This is a method based on a scientific test plan method, which is to to implement effective testing in advance.

Quality engineering tells that quality should be incorporated in the upstream process. This means that upstream process needs testing for quality. Recently, the W-shaped model as shown in Figure 2 supersedes the traditional V-shaped model. The

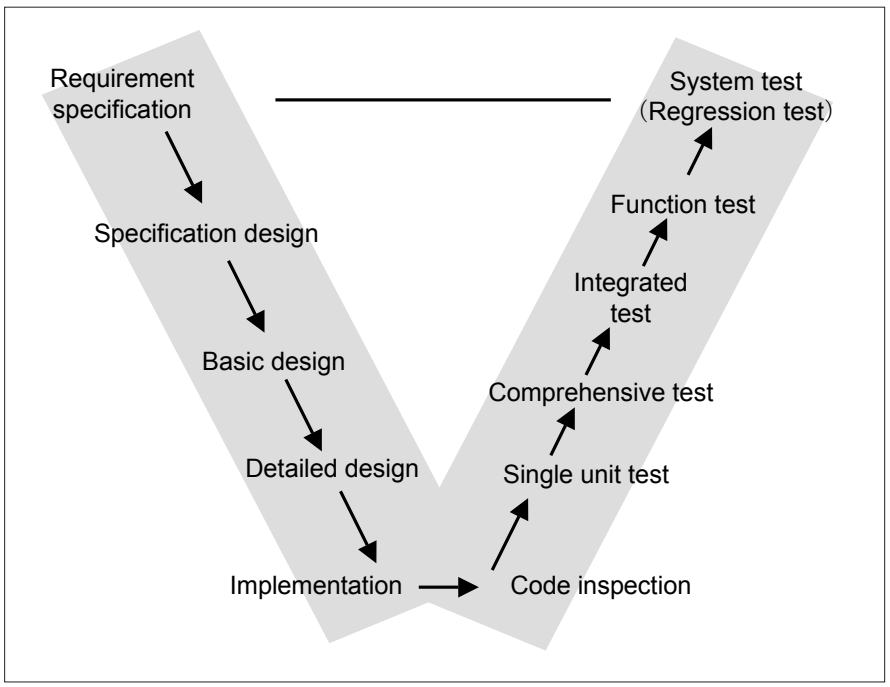

Figure 1 : V-shaped model of development and test (conventional)

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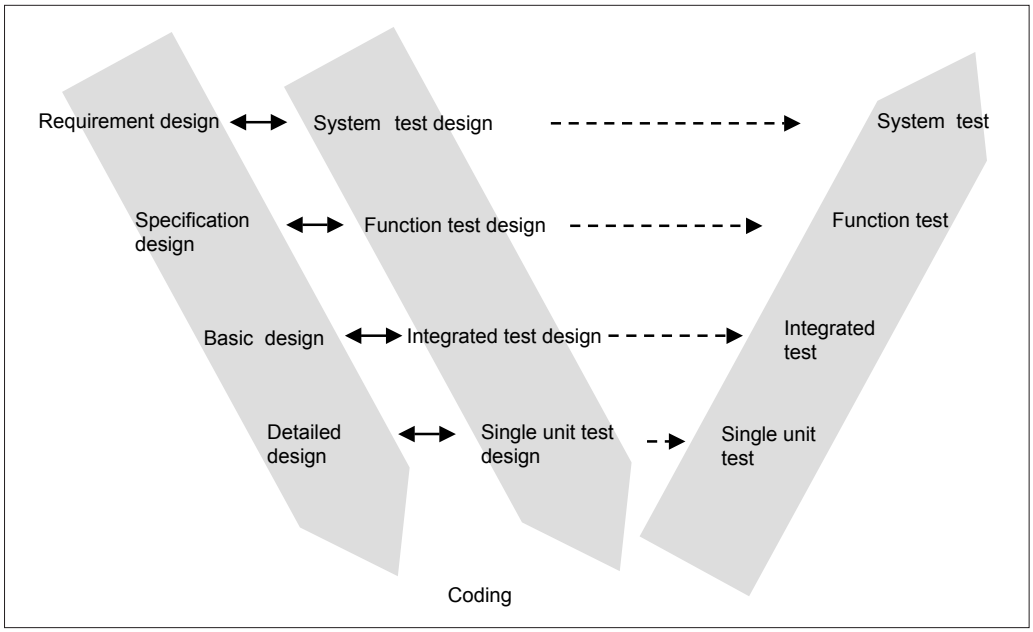

Figure 2 :The "W"-shaped model for software development and tests (the most recent model)

Prepared by the STFC

two large downward arrows in the left of Figure 2 represent a waterfall development of traditional software development, which was referred as a linear development in "Information and Communications Technology and Shiso – Shiso as a Capability for Science and Technology".[24] However, horizontal arrows indicate that test designs will be conducted with the development in each phase. Even the pre-development requirements phase will be accompanied the system test design and testability consideration. While the system test itself will be conducted in the final phase, the test design and testability investigation may correct failures in the upstream.

The W-shaped model creates a test program in line with the program design in the same manner of Agile Development Method. However, while Agile Method requires programmers who write a program would conduct the test, the W-shaped model assigns test engineers, not programmers to do the test.

Some idealist claims that in the future, special quality software could be produced which could avoid testing. However, it is impossible to omit a test for any products or systems today, and most likely even in the future we still need testing. Moreover, software is growing further complicated and larger in scale, and it becomes more difficult to create a perfect flawless program. Hence, it is crucial to manage software risks by the effective tests of the existing and under development software. If we extend the principle of "testing accompanies with development" to the principle of "test is created before development, and development should proceed to satisfy the test", it will produce the framework of the test driven development methodology (TDD) described in Chapter 3.

Since the software is invisible, it would be effective to apply requirement testability and TDD for the software development. These methods can be applied for software in a wider sense, such as laws and regulations. Industrial efforts for "visualization" and "performance evaluation" can be an indication for the effectiveness of these testability/test-driven approach.

5-2 Static test

Software tests employ static and dynamic techniques. Dynamic test is to execute a program and analyze the results. The static test is to analyze a program text without executing a program. "Test" section in "Guide to the Software Engineering Body of Knowledge"[25] refers to dynamic techniques, while the static testing is categorized in "Verification and Validation" section. However, other software test textbooks include the static test in the part of testing. The static test includes human-based activities such as "review" and "inspection" as well as computer-based analysis and data processing such as "metrics", "coding rule inspection", "static analysis" and "model checking". While the dynamic test can be done without special knowledge, the static test can only be performed by specialists. Its advantage lies in its prompt feedback to the development team because it is done in the midst of development process rather than after the development. Static test can improve development process and human abilities.

In terms of quality improvement of system development, it is necessary and efficient to ensure the quality in the upstream process.[11] This is also true for software testing. A method called "model checking" now gains a keen attention in a design phase.[26] The model checking is especially useful for the time critical system which is difficult with dynamic testing technique. The model checking does not test software itself but build a model of the system and test the model using a verifier. The system including hardware and software is represented as a state transition machine with temporal logic. There are skeptical opinions whether it is appropriate to include model checking in the software test technology, Not many software testing textbooks include model checking. While this technology has a long history as an automatic Theorem Proving or mechanical proving method, various tools have been developed recently and effectively used. SPIN[27] is the most widely used tool.

5-3 Automation of software test

In general, the workload of software test would increase exponentially with software size. This is because when the number of conditions increases, the number of necessary tests also increases. To overcome this issue, it is natural to adopt the automation of tests with the accompanying quality

and efficiency. The following methods are available for software test automation.

- Automatic generation of input load such as load tests on the Internet
- Automation of tests by test script languages such as TTCN-3
- Automatic generation of test cases using UTP (UML Testing Profile) etc.

On the other hand, there are critical opinions against the introduction of automation tools.[28] This is because the ad-hoc automation or random introduction of test tools produced confusions. In order to succeed in automating a system, an adequate and enough preparation is needed such as to develop human resource of skilled engineers and to nurture the necessary environments to produce successful results.

6 *Software test industry*

Increased importance and workload of software tests has let some companies to outsource the testing activities to other companies. This is mainly because it is required (1) to decrease the cost related to testing, (2) to adjust manpower in a limited time frame and (3) to get specialized knowledge and skills in testing from outside. In particular, the number of test required for recent embedded systems has become enormous, so companies tend to rely further on outsourcing. With this circumstances, IT Verification Industry Association (IVIA)[29] was established in Japan in 2005, which has 47 member companies as of March 2008. IVIA has divisions such as Technology, Standardization, Education/Training and Alliance etc., and especially puts their efforts on the skill certifications for test engineers. According to IVIA, the companies in test industries reached around 1000, and 100million yen sales. They view this industry has a strong potential of growth.

While it is true in software development in general in Japan that test engineers of large companies has more skills than those who are individual contractors or of small and mid-sized companies, large organizations tend to treat tests as lower class than planning, development, manufacturing or sales so that newly-hired or temporary/extra workers are considered to be enough for testing. Moreover, even a test period could be significantly shortened to compensate the delay of development, which represents a distorted situation that the local politics gains precedence over the fulfillment of testing activities which has an overall importance for quality. This is another reason to bring the birth of test industry.

This movement of independent test industry happens not only in Japan but in India where software industries is booming as a major national business. For instance, an Indian company specialized in software testing named STAG has their office in Japan and the United States. Infosys, the largest software company in India has Independent Validation Center (IVC). This is an individual organization within the company with 3000 employees and rapidly growing. IVC has Chinese Walls for software that is developed by Infosys.

These testing companies and organizations have increased because the software usage has increased and the companies who try to use the software are not able to afford personnel to test the software. In the current circumstance where new technologies are introduced every month while software gets more complicated, it is more effective to employ specialized companies or organization to do the testing job in terms of cost, work period and quality. Infosys IVC is capable of maintaining a knowledge base to evaluate requirement specification according to its development schedule, work items and expected results. Specialized companies are able to use their experiences based on many actual cases, so that their know-how could be utilized by outside companies.

7 Education of test engineers and designers

The needs of highly skilled IT personnel have been discussed in many occasions for the past few years. However, these discussions have not come to the need for personnel for software test yet.[18]

In fact, the needs of software test specialists have been discussed by concerned parties for years. However, very little attempt has been conducted by universities or colleges to have a special course on software testing. In the reference[21] published in

1999, no student has got software test course and the situation was regarded as hopeless.

In Japan, IVIA, the software test company association as mentioned earlier, and other Non Profit Organizations have been providing a certification for software test skills. One of the most representative organizations is Association of Test EngineeRing (ASTER) established in April 2006. ASTER holds an annual software test symposium called JaSST to encourage technical and human development in the field of software testing.

There is a world-wide organization named International Software Testing Qualifications Board (ISTQB) supporting skill certification for software test engineers.[31] According to its website, 39 member countries are participating including Japan as of February 2008. ISTQB's member organization, called Japan Software Testing Qualifications Board (JSTQB) provides certification for software test engineers.[32] The website of JSTQB shows the data about the number of certified engineers in 20 member countries and regions. It shows that there are about 24,000 certified engineers in the world and more than 1000 in Japan. Information-Technology Promotion Agency, Japan (IPA) has developed ITSS (IT skill standard) and ETSS (embedded software skill standard). ITSS "systematically summarizes abilities/skills required to provide various IT related services, and to provide a scale (common framework) effective to measure the level of performance of IT service professionals in the academia and industries". ETSS aims to "enhance the human ability for embedded software development and to develop mechanisms to achieve human resource development and exploitation for embedded software development".

ITSS was originally developed in 2002, and has "testing skill" in its skill item for system, database, network and other function skills required for IT specialists. For application specialists, "testing skill" is found among the required methodology for software engineering. However, there is no job category for testing specialists. In the job category of consultant or IT architect, no testing skill is included. Only the various testing related skill items are listed.

Meanwhile, ETSS developed in 2005 lists "test engineer" as a job category, because test engineers are much more important for embedded software. ETSS specifies required skills for test engineers.

Japan Electronics College has established a new course called Software Test Design Course in April 2008 to cope with the recently increased demand of software test specialists. This 2-year course provides curriculum for test engineering. According to its website, the course addresses: testing method, testing environment development skill, test management skill, performance evaluation skill, quality management, idea development skill, embedded system, and case studies. The pre-requisit skills and knowledge are also handled including computer in general, programming, and networking skills. The college says that many companies are interested in employing the graduates so that the students need not worry about their employment. However, there is a concern if high school students could have a favorable impression on the word "test".

Looking at the education overseas, for instance, IT companies in India are famous on their employee training. In the human development program of IVC in Infosys, they aim at not only testing skills but also other skills in technology, quality, process, application and even behavioral abilities such as leadership and communication skills. They also provide career opportunities for test engineers to become the board member in testing divisions.

Product tests are not just a series of trial use. To conduct a test will require special knowledge about the product and the user. Test engineers must precisely understand the product perspective with its strategy and value proposition, which is equivalent to understanding of the status, strategy and value of the organization for the product. That is, test designers/engineers should share the sense of issues that the corporate management have.

In this sense, those who are capable of leading software testing are very valuable, so that there might be a discussion whether it is appropriate to have them just to handle testing. Human resources related to software testing should play a significant role to evaluate various risks related to quality of products as well as to ensure the "quality of organization". Likewise, it will be necessary to foster software testing engineer/disigner/manager

in the advanced education in universities and graduate schools. Enterprises are also required to promote the personnel who are specialized in software testing to higher states/positions.

8 Software risk management and its future

Software test specialists are required to have communication skills to talk to development engineers to avoid any unwanted defects in quality of products, as well as specific test skills. Moreover, from the viewpoint of risk management, it is required to have management skills to consider the influence of inconvenience due to the society in large. Nonetheless, some companies are still putting beginners on the testing job considering that they can do the test without any special skills. Software are becoming further complicated and the whole world is relying more heavily on software. Therefore, even though software test technologies will advance, our concerns on serious software accidents will continue to exist and to grow. Considering the significance of risk management, it would be necessary to create a social framework to this issue. This is also related to the needs of compliance in recent years.[33-38] Hence, here is a proposal for software risk management in a wider perspective.

8-1 Knowledge sharing through the establishment of accident investigation committee

In case when any failure of software system occurs that could affect the society, the accident investigation committee analyze the software system thoroughly to prevent similar accidents, and our society and engineering community can learn these lessons to advance the software systems. There would be several possibilities how to form such committees. One would be to consist of contractor and owner/orderer. The other is to have outside organization where the concerned party would not participate in. Their mission is not to determine who is responsible but only to analyze why the accidents have occurred. In the current government, local or central, procurement operation, most are divided up according to work phase, so that multiple contractors are participated to make a whole system. If any accident occurs, various parties would be involved, and this will add the complexity to handle the problems.

8-2 Software test audit by the third party

Software systems that may affect the society should require audit by the outside third parties other than the owner/orderer and contractor. This auditor will compile the results with the software test and put the documents in the third party archive. Once any inconvenience occurs to the system, any people to solve the problem will immediately access the archived record and act any adequate operations. Such organizations are required to have the capability of comprehensive quality evaluation and risk management including extensive software testing capabilities.

8-3 Legal systems to handle software failures

The current product liability laws (PL Laws) would not apply to software. However, as there are requests to apply PL laws even for software because accidents could occur by the failure of software of the system, there is a possibility that the law will be enforced for product liability concerning software. In this case, it is desirable to have laws and regulations to minimize any damages of accidents. This may handle - the current software license agreement (End User License Agreement, EULA) - which claims entire product liability to the producer. One issue would be how to control potential damages due to the modification by users or outside parties, while promoting the technical development.

8-4 Study on terminology, description and representation, and basic knowledge of software

Software related accidents and problems may only be attributed to software specialist, and the organization on the whole may not understand the issue. This may lead to a neglect of software quality because it is not perceived as the issue for whole the stakeholders. In order to avoid this situation and to share the successful results of e-Japan strategy by all citizens in Japan, it is necessary to make efforts to promote researches on software terminology, description and representation so that general people and managers of organization can

easily understand software related accidents and issues. Activities for training and proliferation for software to general public would also be required.

These kinds of activities described from 8-1 to 8-4 have potentials to bring an opportunity to review the quality of Japanese systems including products made in Japan, and to be an activity to widely provide quality related services not only to a company but also to the society, which is "industrialization of quality", so to speak. If software test is treated from such viewpoints, investment in software test personnel including researchers, designers, engineers and managers will not only enhance the industrial competitiveness of Japan but also to create a new knowledge industry to contribute to the safety and security of Japan and the rest of the world.

9 Conclusion

As software tests have been conducted as a final process in conventional software development, some are mixed up with debugging, which caused problems. Now, in recently years, software test as a quality assurance and risk management activity gains a lot more attention and appreciation.

This is because embedded software system has become widely use, though which has led unexpected troubles by unexpected use by users. Some troubles have had caused a significant influence on our daily lives. These problems cannot be solved only by debugging, but by conducting various software test both in and around the system where every possible cases are covered. Technical development and system and environmental maintenance should be conducted to create a quality and reliable software, along with the promotion of software test development, fostering its specialists. In fact, due to both the importance and difficulty of software test, new companies and organizations specialized in software test have emerged and their business is steadily growing.

These are "industrialization of quality" of software so that it should be emphasized that investment in software test researchers, designers, engineers and managers would not only enhance the industrial competitiveness of Japan but also to create a new knowledge industry contributing to the safety and security of the country and the world.

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3

The Modal Shift to Environmentally Sustainable Transport: Prospects of Urban Transport Systems: LRT, BRT and Buses

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1 Introduction

In 2007, the Fourth Assessment Report by the IPCC (Intergovernmental Panel on Climate Change)[1] concluded that the recent rise in average global temperature is "very likely" due to a human-induced increase in greenhouse gases (GHG). The panel stated that implementing appropriate measures in the next few decades could reduce these emissions.

One proposal to mitigate these emissions called for a modal shift from cars to public transportation. To make this happen, it is vital to develop policies that push for change in the lifestyles and behavior patterns of car-dependent societies.

Interestingly, many European cities have actively promoted the use of public transportation since the 1980s, a period known for the opposite: motorization. City residents motivated this mindset by voicing their desire to rebuild their towns that had been taken over by vehicular traffic. Implemented measures have decreased air pollution from traffic congestion, and have preserved historical sites by reducing the environmental burdens placed upon them. It was around this time that trams, which had all but disappeared after World War II, began to reappear in Europe.

In 1996, the OECD referred to this European phenomenon as the development of environmentally sustainable transport (EST). Four years later, the organization incorporated its latest ideas into the EST guideline.[2] The guideline presented different viewpoints regarding public health and socioeconomic concerns raised by EST.

Today, Japan acknowledges EST as an appropriate means to mitigate global warming. It is also considered key to achieving a compact city*1 in the future. In Japan and abroad, relatively low-cost urban rail systems called Light Rail Transit (LRT), as well as articulated buses known as Bus Rapid Transit (BRT), are being actively introduced to many cities as a part of this initiative. Compared to conventional trams and buses, these modern machines look futuristic and highly sophisticated, but its appearance is not the only thing that is revolutionary. With advances in technology, these systems could evolve into other forms of public transport that does not fit within the current framework.

By focusing on the technological trends that are shaping the future of LRTs, this report discusses the outlook of urban transport.

2 The inevitability of a modal shift to public transportation

2-1 The now and future of car-dependence

In 2004, the World Business Council for Sustainable Development (WBCSD) performed a study on global mobility trends up to year 2050. This report, titled Mobility 2030,[3] indicated an

Glossary

*1 **Compact city:**
A widely implemented concept aimed at resolving the inherent problems of suburbanization. With more cars due to motorization, residential and commercial districts often tend to decentralize from the city center. This move creates social problems such as reduced efficiency of human/goods transport, suppressed economic activity due to urban sprawl, and increased health risks caused by an overdependence on motor vehicles (refer to 2-4 for details).

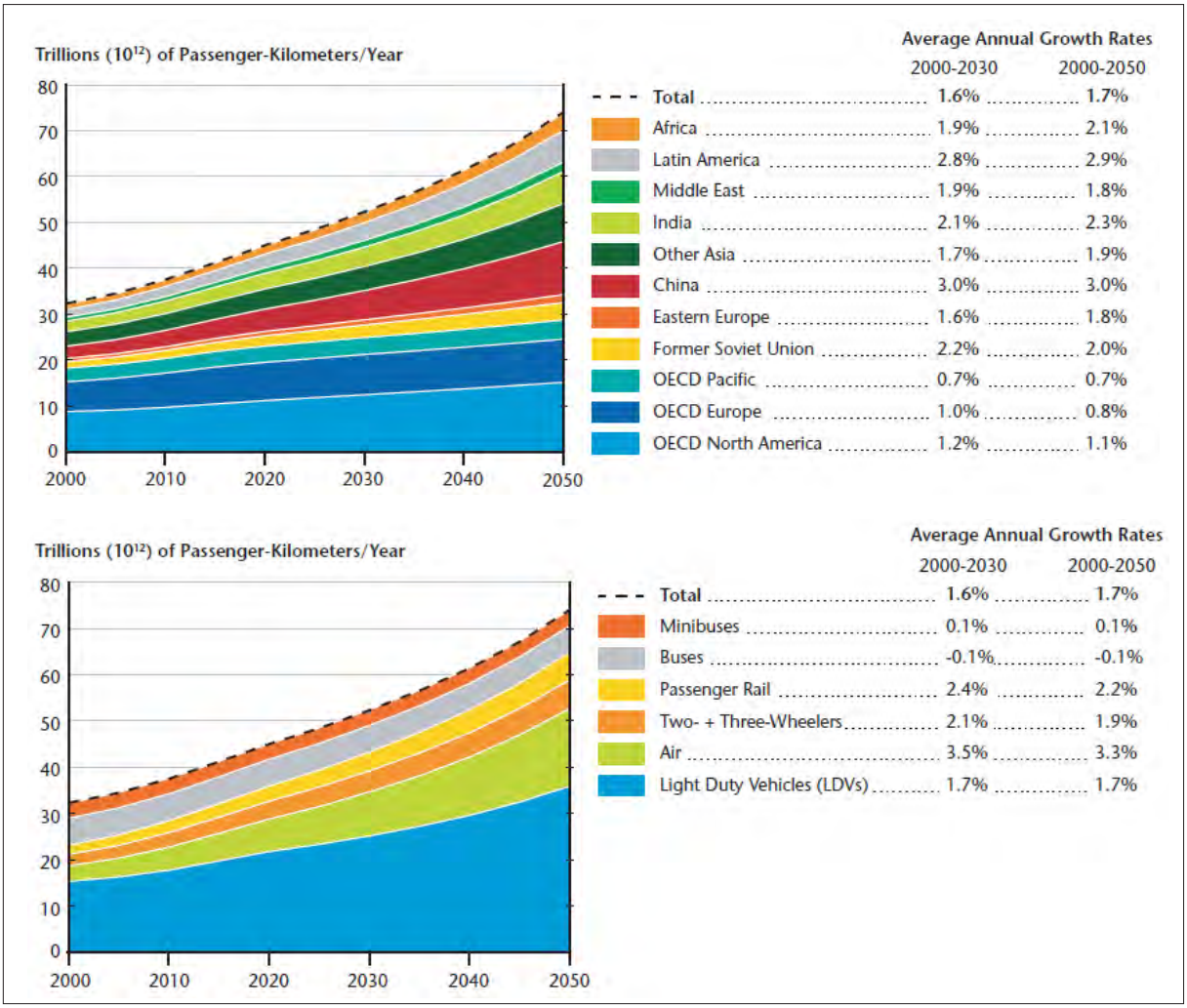


Figure 1 : Personal transport activity

Source: Reference[3] (original source: the United Nations (UN) 2001, WBCSD Mobility 2001)

upward trend in human mobility (Figure 1). This tendency was attributed to the sustained growth of car ownership caused by factors such as rising per capita income. In particular, it forecasted a significant increase in the number of cars owned throughout Eastern Europe, the former Soviet Union, Latin America, and China for the next several decades (Figure 2). This rise was predicted to be due to the rapid growth of per capita GDP in these developing countries.

However, there are more things to take into consideration. With advances in technology, energy efficiencies of transport vehicles are expected to improve: Estimated energy-reduction rates average 18 percent for cars and 29 percent for trucks and aircraft. However, the surge in cars and the inevitable increase in CO_2 emissions are likely to cancel out the benefits of more efficient systems, resulting in a net increase of GHG concentrations

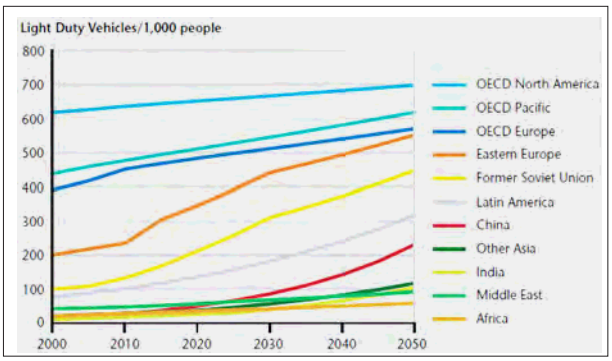


Figure 2 : Projected growth in light duty vehicle ownership

Source: Reference[3] (original source: the United Nations (UN) 2001,WBCSD Mobility 2001)

(Figure 3).

It is important to note that GHG emissions from light-duty road vehicles (LDV) will continue to rise, and will remain elevated in the future (Figure 3). With the increased global mobility, along with the resulting boost in the global economy, the

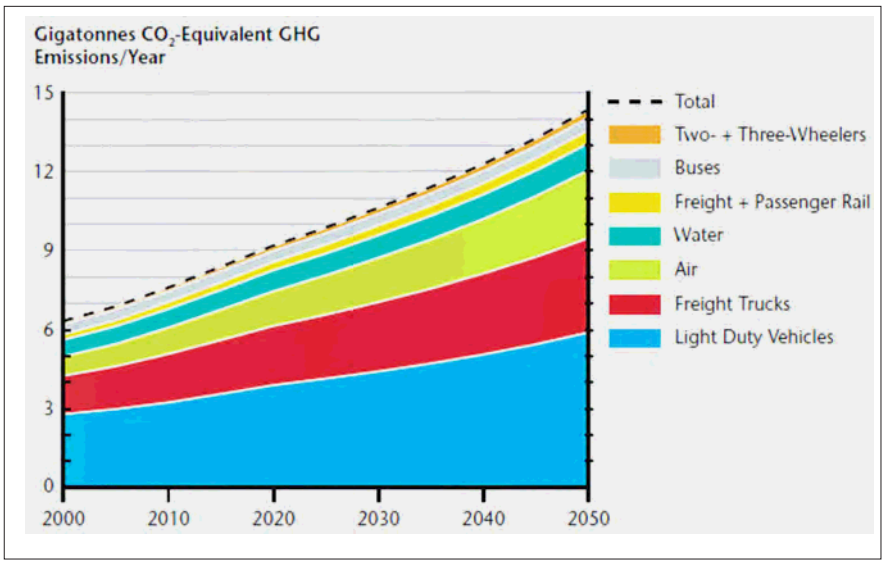


Figure 3 : CO_2 emissions by mode (worldwide)

Source: Reference[3] (original source: the United Nations (UN) 2001, WBCSD Mobility 2001)

Table 1 : Household transportation expenditures

	United States	United Kingdom	Japan
Household Transportation Expenditures as a Share of Total Household Expenditures	19.3%	16.7%	8.5%
Composition of Household Transport and Travel Expenditures			
Public Transportation	5.2%	13.5%	28.7%
Rail	n.a.	3.1%	15.6%
Bus	n.a.	2.2%	3.0%
Taxi	n.a.	n.a.	2.9%
Air	n.a.	2.0%	2.7%
Highway	n.a.	n.a.	4.1%
Other	n.a.	6.0%	0.4%
Private Transportation	94.7%	86.5%	71.3%
Vehicle Purchase	46.9%	36.9%	22.7%
Automobile Purchase	*46.3%*	*34.7%*	*21.2%*
Two-Wheel/Other Purchase	*0.6%*	*2.2%*	*1.5%*
Vehicle Operation and Maintenance	47.9%	49.6%	48.6%
Gasoline/Motor Oil	*16.8%*	*24.5%*	*16.6%*
Maintenance/Repairs/Parts	*8.7%*	*9.6%*	*8.3%*
Parking	*n.a.*	*n.a.*	*7.1%*
Insurance	*10.7%*	*12.7%*	*11.5%*
Other	*11.7%*	*2.8%*	*5.0%*

Notes: n.a = data not provided by source; may be included in "other"

Source: Reference[3] (original source: Japan Family Income and Expenditure Survey, UK DfT2003, US BLS 2003)

growth of motorization in developing countries seems like a delightful concept. From a GHG perspective, however, it is an increasingly alarming situation.

2-2 Rates of car-dependence

To what extent do we rely on cars? Table 1 shows the amount of household income spent on transport costs in the U.S., England and Japan. At 19.3 percent, Americans spent the most amount of their family income on transportation costs in 2003. The Japanese only spent 8.5 percent. A closer look at the breakdown of the costs showed that within the total used for transportation,

Americans only spent 5.2 percent of it on public transportation. The remaining 90-plus percent was used for the acquisition and maintenance of private cars. In Japan, the use of public transportation was overwhelmingly high at 28.7 percent, but the remaining 71.3 percent was used for personal means of transport.

Figure 4 graphs the modal split in preferred means of transportation. Both the U.S. and Europe (EU-15 average) show a high dependence on cars, at over 80 percent and slightly under 80 percent, respectively. At less than 60 percent, Japan's reliance on cars was relatively low, but the modal split was more widely varied in the larger cities (Figure 5). For example, in 2003, car usage was very low in Tokyo at 33 percent, but outside of the three major cities (Tokyo, Nagoya and Osaka), car usage was high, at 84 percent. In less urban areas,

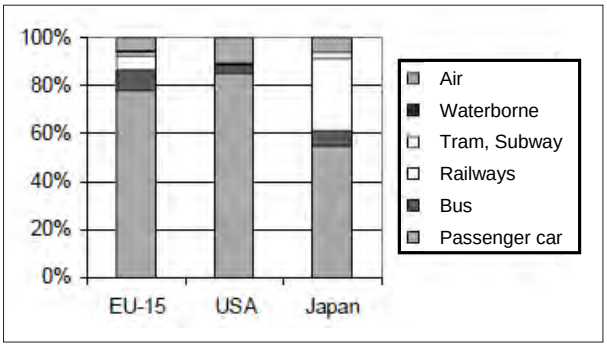


Figure 4 : Modal split of passenger transport by region

Source: Reference[4]

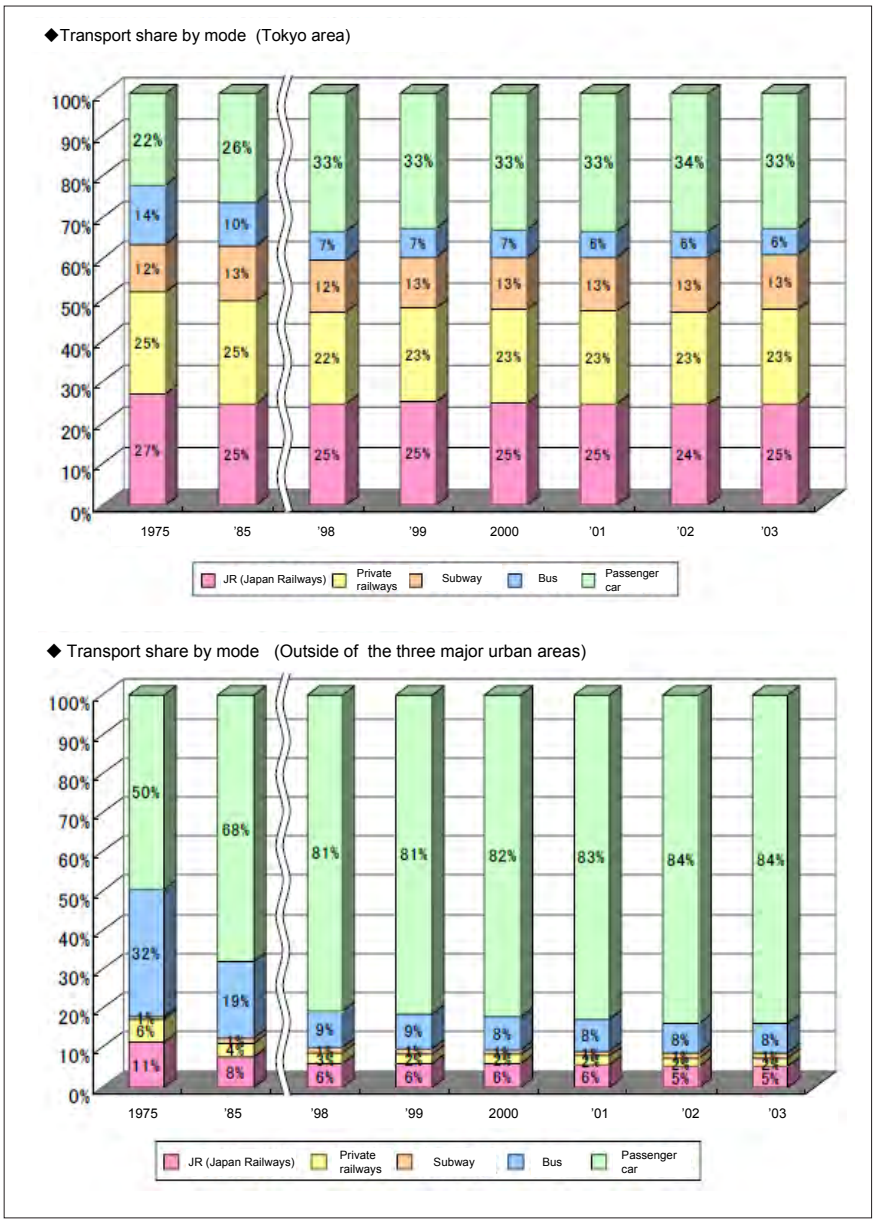


Figure 5 : Modal split of passenger transport in Japan

Source: Reference[5]

railway usage was extremely low, at 8 percent. From this, we can conclude that in Japan, car dependence is high in the smaller regional cities and less urban areas.

2-3 Difference of environmental burdens depending on the mode of transportation

The problem with car-dependent societies lies with its large impact on the environment. Figure 6 compares energy consumption and CO_2 emission of various modes of transportation. Cars show high figures for both categories, emitting more than ten times the amount of CO_2 compared to trains, and over twice the amount of buses. In order to mitigate global warming, we must reduce the amount of environmental burden per unit transport. Figures such as this make clear the importance of public transportation.

However, the two basic concerns with public transportation are its accessibility and the degree to which its use and convenience integrate with existing lifestyles. Unless favorable preconditions are in place, a spontaneous transition to public transportation is going to be difficult to achieve.

In Japan and abroad, the LRT may be the answer to these societal demands. These trams have begun to appear on city streets, and are considered an essential tool in creating more innovative cities.

2-4 Addressing problems arising from car-dependence

Following the growth of motorization in the 1970s, residential areas and shopping centers have sprawled out to the suburbs on the premise that people are commuting by car. As a result, city functions have spread extensively and have become more fragmented. This is known as the sprawl effect. This phenomenon leads to many societal problems such as (1) significant loss of time and energy from transporting goods and people, (2) increased risk of lifestyle-related diseases due to less walking, (3) unfair limitations imposed upon children and the elderly who cannot drive, and (4) decline of economic activity due to reduction in population density.

The widely implemented idea to achieve a compact city was developed to fix these problems. This concept aims to solve both business and housing issues to rebuild a lively and compact city. One key to making this sort of city-building a reality is the incorporation of a new transportation network, the LRT. By connecting residences, businesses, hospitals, schools, stores, government buildings and other necessities via LRTs, people are able to live in a compact city where foot travel is possible.

Compared to areas that have been developing policies since the 1980s like the U.S. and Europe, Japan is still far behind. However, the compact city policies passed in 2006 will enable us to catch up at a rapid pace.

2-5 An example of a city with LRTs

This section discusses Toyama as an example of a city that has successfully incorporated LRTs to achieve a compact city.[7]

Before it all began, Toyama had the lowest population density among densely inhabited districts of all prefectural capitals in Japan. Its city-center was hollowing out, and residents were purchasing large numbers of private cars and suburban homes. Due to the reduced efficiency

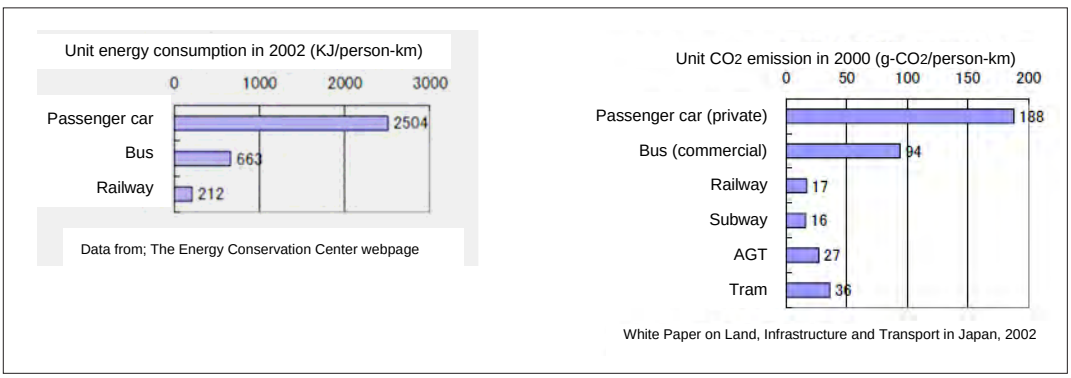


Figure 6 : Units of energy consumption and CO_2 emission by mode

Source: Reference[6]

Figure 7 : LRT in Japan ; Toyama city (left) and BRT in Europe; Eindhoven district, the Netherlands (right)
Source: Reference[8](left),[9](right)

caused by the urban sprawl, Toyama faced increasing financial costs to maintain and develop roads, as well as to provide public services that require movement of personnel and goods. These services included welfare work, garbage collection and snow removal. Additionally, as train and bus companies began to cut routes to cope with decreased demand, trains and buses became more inconvenient, starting a vicious cycle that attracted fewer and fewer riders. Notably, this made life difficult for the children and the elderly who already had less access to transportation.

From this, Toyama formed the Compact City Development Group in 2003 and began working toward developing a compact city through collaboration with residents, businesses and the local government. The core of this plan was the introduction of a new transportation network, the LRT.

There are two basic methods for achieving a compact city. One is the monocentric approach, which creates one large concentrated city center, while the other is the polycentric approach, which builds multiple interconnected small cities or facilities.

Toyama used the polycentric approach and connected already-existing facilities with LRTs. From this, Toyama was able to make public transportation available within walking distance from anywhere in the city. By making all necessary facilities readily available, they aimed to create an urban environment where foot travel is feasible.

3 Urban transport technologies (LRT, BRT, Buses) and their benefits

3-1 Functions of transport systems

Figure 7 shows an example of the recently introduced LRT and the BRT. With a futuristic appearance, these systems possess unique characteristics that are both technological and societal in nature. The basic purpose of these systems is to provide what was previously lacking in the public transportation sector.

Figure 8 graphs the operating speed and transport capacities of the LRT and the BRT. In the past, there has been a wide gap between city buses and Automated Guideway Transit (AGT) systems (including monorails) and subways on this graph. To deal with this discontinuity, trains and city buses were used to support the main framework of the public transportation system.

As shown in Figure 9, one kilometer of subway track costs 17 to 30 billion yen to build. For an AGT, the same distance would cost about 7 to 15 billion yen. Due to these high construction costs, city buses were the only alternative in many cities that did not have enough riders to justify the costs of the aforementioned systems. Recently introduced LRTs and BRTs operate at speeds close to that of a monorail while only costing 20 to 50 percent of what it would have cost to build one, bridging this so-called transportation gap.

For these reasons, LRTs and BRTs are expected to improve the quality of the public transportation

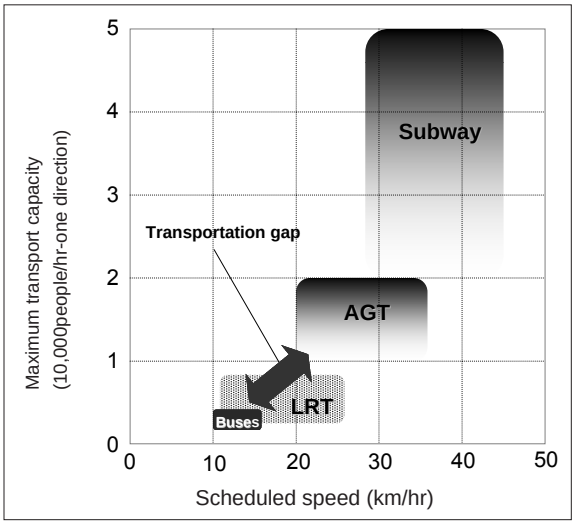


Figure8 : Capability of public transportation

Prepared by the STFC based on Reference[6]

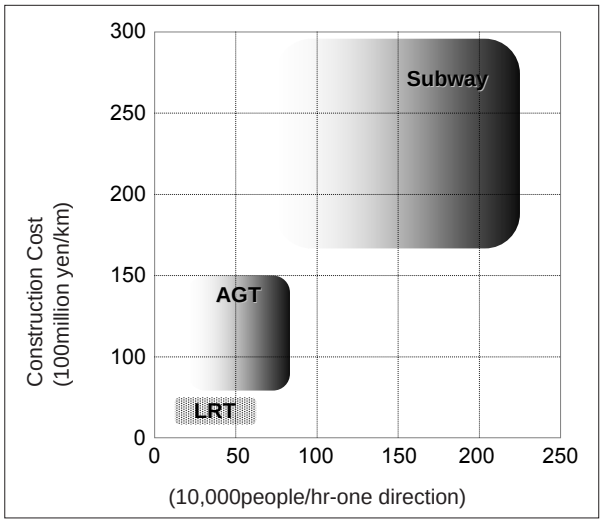


Figure9 : Construction cost of public transportation

Prepared by the STFC based on Reference[6]

sector and become a mainstay for a bright future in city building.

3-2 Basic characteristics and societal benefits and profits

LRTs have several characteristics that will benefit society that have not existed in the past. The most notable of these technologies would be the low-floor capability and the onboard IC-card ticketing system. (Figure 10)

Low-floor vehicles came into being through the innovation of existing drivetrain systems (wheels and axles, motor and gear) (Figure 11). As opposed to connecting the wheels below the vehicle floor with an axle and powering that with a motor, the new systems completely do away with the axle and incorporate a separate motor for each wheel. As a result, the floors of these vehicles are only about 30 centimeters above the ground. With vehicle floors this close to the ground, not only will the cost to build platforms be reduced, but the distance between the road surface and the platform will also be shortened, minimizing the time passengers have to take to get on and off the LRT.

Also, due to the introduction of the onboard IC-card ticketing system, passengers no longer need

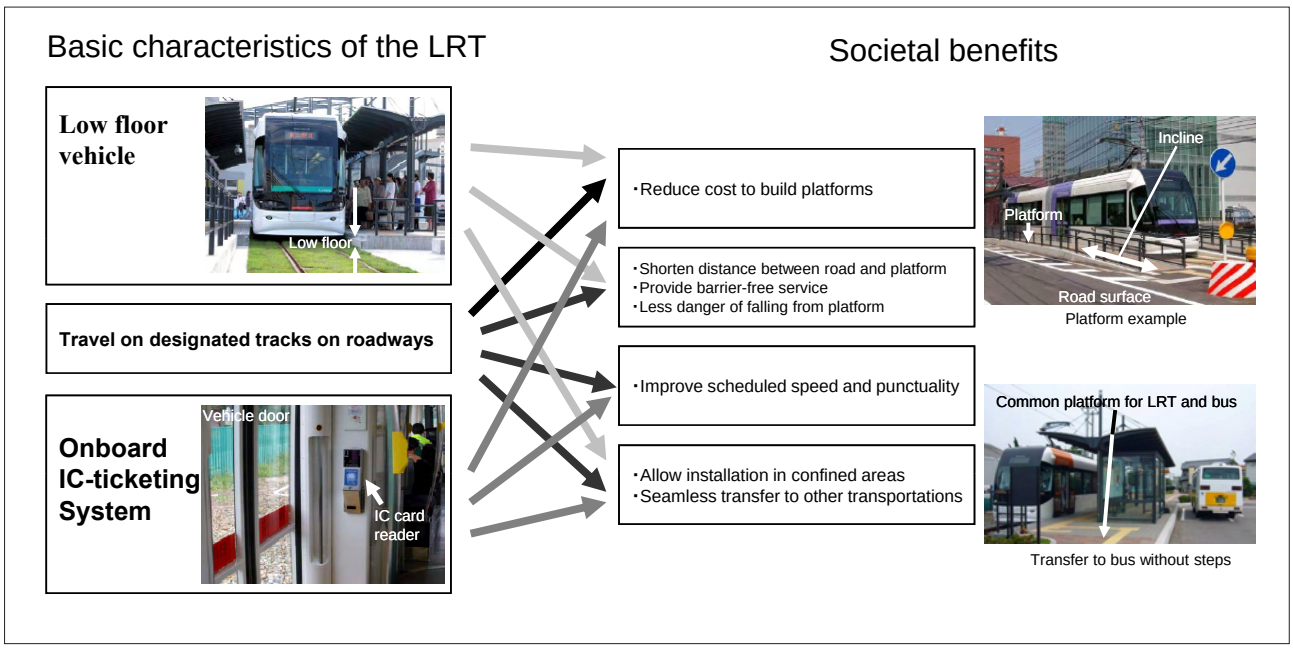


Figure 10 : Characteristics of LRTs

Prepared by the STFC based on Reference[10]

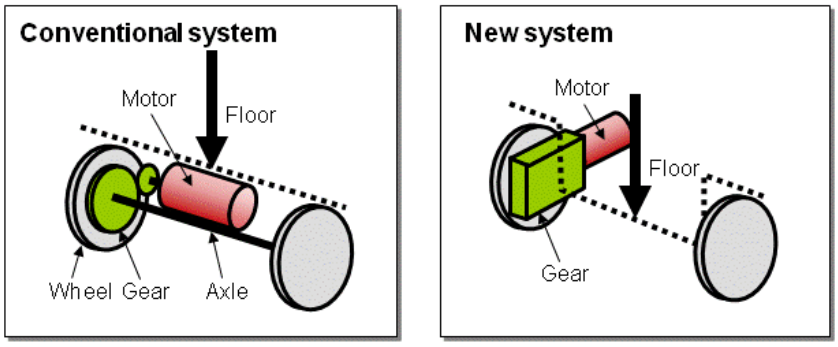


Figure 11 : Example of LRT drivetrain system

Prepared by the STFC based on Reference[11]

Table 2 : Category of urban transport systems (LRT and BRT)

	Power source		Steering mechanism	
	Drive mechanism (energy type)	Energy supply method		
LRT	Electric motor (electricity)	Overhead wire 	Tracks (rail track)	2 tracks 
		Groove embedded on road surface 		1 track (+wheels) 
BRT	Engine (fuel)	Fuel tank	Steering (wheels)	Automatic steering (follows road surface marker) 
	Hybrid (electric motor + engine)			

Prepared by the STFC based on Reference [6,12]

to go through a separate ticketing gate, requiring less overall effort. Furthermore, since the incline from the road surface to the platform can be made extremely gradual and confined within a relatively small space, the handicapped and the elderly will be able to board without assistance. Lastly, by having bus stops and platforms for the LRT at the same level, passengers can make use of a seamless public transportation network.

3-3 Technological characteristics of urban transport systems (LRT and BRT)

Table 2 shows the technological characteristics of the recently introduced LRTs and BRTs categorized by power source and steering mechanism. There are two energy sources that can power the LRT and the BRT: electric motors and engines. The LRT primarily uses electric motors (Figure 11). There are two ways to obtain electric power: through overhead lines that parallel the tracks or

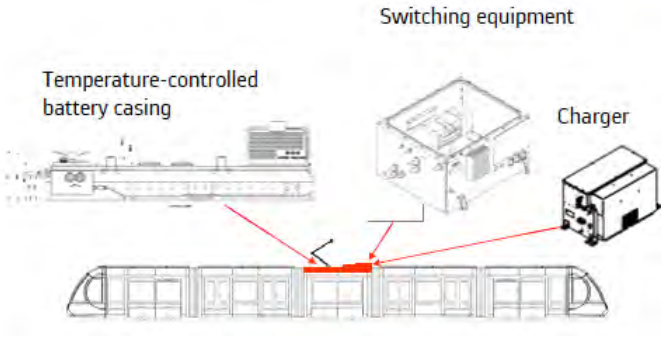


Figure 12 : Battery-equipped LRT introduced in France, Nice (a product of ALSTOM)

Source: Reference[13]

via a third rail embedded inside the road surface. In order to obtain power from the overhead lines, supporting structures such as poles and buildings become necessary, but the process is facilitated if said structures already exist along the route of the tracks. In Europe, the third rail system is becoming more common due to concerns of visual pollution and damage to historical sites. However, their engines are based on the BRT.

There are two different steering mechanisms: a system where steering is not required as the vehicle is guided by tracks, and a system where conventional wheels steer the vehicle. Trains that run on tracks are further divided into two categories. The first kind is the dual-track type where two wheels move along two parallel tracks. The other type is the single-track type. In this configuration, the vehicle is guided along a single track that runs underneath the center of the LRT. The LRT itself is supported by conventional rubber tires, but they do not do the steering.

One advantage of the LRT is the ease of snow removal. This facilitates stable operations throughout the winter months. Another advantage is that the bumps and swaying motions are reduced. This provides passengers with a smooth, comfortable riding experience that making the LRT a friendlier form of public transportation.

In recent years, hybrid BRTs have become more popular, incorporating both electric motor and engines. These hybrids serve a dual purpose. They are environmentally friendly in the way that it mostly runs on electricity, but at the same time, it allows for the expansion of the BRT network by running an engine where overhead wires are unavailable. Additionally, for vehicles with steering capability, there are white lines and magnetic markers that mark its movement area, increasing the accuracy of its operation and reducing the gap between the platform and the vehicle entrance. However, the unit cost for these hybrid BRTs is expensive.

3-4 Recent technological trends

In recent years, there have been notable improvements in the area of battery-equipped LRTs. In December 2007, a battery-equipped LRT was introduced in Nice, France (Figure 12). Although it runs on the electricity obtained from the overhead wires, these vehicles are able to travel on battery power for as long as one kilometer with a maximum speed of 30 km/h. Since it is able to run without the overhead wires, these LRTs are able to operate through the historical Place Massena and Place Garibaldi without causing visual pollution or harming its historical character. Upon entering an area without overhead wires, the pantograph is folded, and when it returns to an area with electric power, it is re-extended and begins recharging the battery. Although the ability to operate on battery power is still restricted to one kilometer, its societal benefits are significant: it enables public transportation to reach the crowded shopping areas and tourist spots while protecting the scenery and the historic qualities. With many valuable historic sites to protect, Europe is expected to incorporate more and more of these battery-equipped LRT technologies in the future.

Even Japan is starting tests on battery-equipped LRTs. Table 3 is an example of an LRT running on nickel-metal hydride batteries. Testing began in November 2007 with the goal of achieving 10

kilometers of travel on battery power after a quick five-minute contact recharge. Table 4 is an example of an LRT running on lithium-ion batteries. Testing began in October 2007 with the goal of achieving a 40-second recharge under 1000A and a three-minute recharge under 500A. Both vehicles in Tables 3 and 4 are in the process of collecting necessary data for the operation in climates with harsh winters, and are projected to launch in the near future.

On the other hand, there have been ongoing research and tests on electric buses that incorporate a non-contact power feeder technology. Figure 13 shows a low-floor electric minibus that has a non-contact power feeder underneath the bus chassis. When it is not moving, the bus recharges its battery through electro-magnetic induction from the road surface without physical contact. In this case, power-feeding efficiency is as high as 90 percent. Figure 14 is a large hybrid bus incorporating the same technology, with ongoing tests since February 2008.

In terms of battery-equipped vehicle technology, Japan is slightly behind, but we are rapidly catching up. Since Japan has a strong background in battery technology, once caught up we expect to develop technologies that enable long-distance travel on one charge. With testing of non-contact rapid power-feeding technology underway, we expect to see a substantial increase in the operational range of these vehicles.

4 The analysis of the present and the expectations of the future

4-1 Japan's current situation

(1)Convenience and network expansion capability

As described in previous sections, low-floor vehicles and LRTs with onboard IC-card ticketing systems are making public transportation more convenient than in the past. For example, according to a study of the LRT introduced to Toyama in 2006, ridership among seniors above age 60 has increased. Compared to before the LRT introduction, senior ridership has increased by 3.5 times on weekdays and 7.4 times on weekends. Ridership among the elderly is increasing: seniors comprise 30 percent of weekday users and 43 percent of weekend users.[19]

By building the platforms for LRTs and buses the same height, passengers can enjoy smooth, seamless transfers between different transportation networks. Thus, many transportation networks that share the same road surface have expanded. In the future, when minibuses start incorporating these electric-power and low-floor technologies, the transportation network will reach every corner of the city.

However, there has not been enough thought regarding passengers who are transferring between LRTs and existing train lines. In Japan, unlike many countries in Europe, there are many cases where train stations exist far above the ground, as well as deep underground. In order to increase the convenience and improve the accessibility of the transportation system as a whole, it is vital that we take steps during the planning stages to develop a system that cuts down on walking distance.

(2)Safety

Safety concerns exist in countries such as Japan, because people are not used to systems like the LRT operating in such close proximity to cars and pedestrians. There have actually been some reported accidents where LRTs were involved.[20] In many instances, the driver, who was unaware of the approaching LRT, had decided to make a right turn. Unable to stop in time, the LRT would end up hitting the car that was blocking its path.

New LRT tracks that are embedded into the road surface are partially fixed with resin to reduce noise and vibration. Unfortunately, this creates the possibility where drivers have a hard time becoming aware of the existence of LRTs. This problem is not just limited to LRTs; electric-powered buses and cars have the same problem.

Since the entire body of the LRT is completely covered, the wheels are not exposed. Due to this beneficial feature, there have yet to be a tragic accident involving a person becoming caught in the wheels.

As such, it is believed that residents generally accept LRTs as a relatively safe form of public transportation. In European cities, LRTs even operate in crowded areas quite frequently. However, in the future, the safety should not be entirely in the skilled hands of the driver.

Table 3 : Nickel hydride battery-equipped LRT in field test (a product of Kawasaki Heavy Industries Co., Ltd)

Items	Configuration
Feeding system	600V direct current from overhead wire and onboard batteries
Vehicle structure	3-car, 3-truck, articulated
Total length	15m
Floor height	330mm(door section)/ 360mm(passenger compartment)
Minimum aisle width	800mm
Capacity	62 passengers (including seat capacity of 28)
Maximum operating speed	40km/hr
Designed maximum speed	50km/hr
Main circuit system	Phase induction motor IGBT, inverter controlled
Battery type	Onboard nickel hydride batteries (installed under passenger seats)
Battery capacity	274Ah
Travel distance on section without overhead wire	More than 10km (on normal route)

Source: Reference[14]

Table 4 :Lithium ion battery-equipped LRT in field test

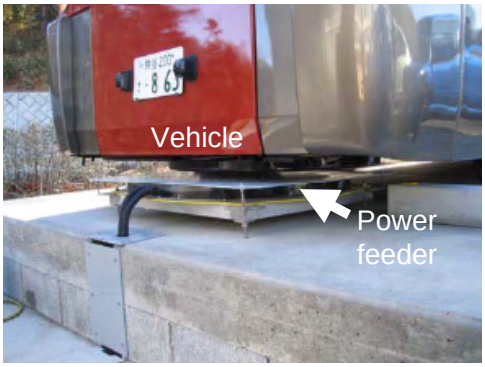
Quick contact recharge from the pantograph

Items	Configuration
Type	LH20 type
Track gauge	1067mm
Capacity	44 (seat capacity 20)
Power supply	Overhead wire: 1500V direct current, 600V Batteries: 600V direct current
Empty weight	24.0t
Maximum speed	40km/h (LRT track) 70km/h (railway track)
Vehicle configuration	12,900(lenth) x 2,230 (width) x 3,800 mm (height with folded pantograph) 350mm (low-floor height)
Truck type	Coil spring indirect mounted bolster truck
Brake type	Regenerating and electricity-accumulative electric commanding air brake
Main motor	Three-phase induction motor, 60kw rated power x four bogies
Main motor control	VVVF inverter, 150kVA x 2 band
Batteries	600V – 120Ah lithium ion rechargeable battery
Battery and overhead power control	Current reversible step up/down chopper, 600kW

(conducted by Railway Technical Research Institute as committed by New Energy and Industrial Technology Development Organization, NEDO)

Source: Reference[15]

Advanced electric community bus (test model)

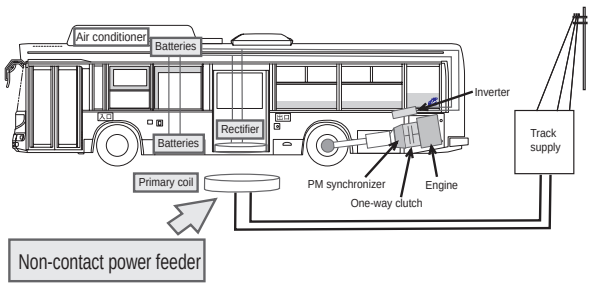


Power feeder installed on the road surface

(conducted by Waseda University, National Traffic Safety and Environment Laboratory and Showa Aircraft Industry Co., Ltd as subsidized by New Energy and Industrial Technology Development Organization, NEDO)

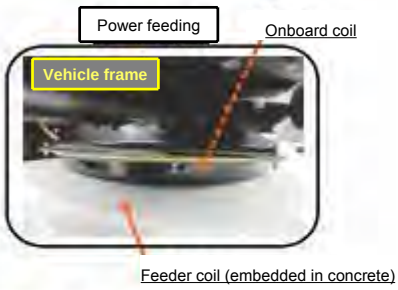
Figure 13 : Electric community bus in field test

Source: Reference[16,17]



Configurations of non-contact power feeding hybrid electric bus

Items	Details
Length x width x height	10.925m x 2.49m x 3.285m
Gross vehicle weight	15.6 ton
Capacity	63 passengers
Battery performance	Enables approximately 15 km-mileage in urban areas with battery electric power alone.



Quick recharging to onboard lithium ion batteries are performed while the vehicle is parked through non-contact electromagnetic induction from the power feeder embedded in the road surface.

Photo provided by Hino Motors, Ltd.

(conducted by National Traffic Safety and Environment Laboratory, Hino Mortors. Ltd. and Ministry of Land, Infrastructure, Transport and Tourism)

Figure 14 : Hybrid bus (engine + electric power) in field test

Source: Reference[18]

It is essential that a device be developed that systematically and mechanically stops the vehicle.

(3)Societal consensus for LRT introduction and its results

Japan only has limited examples of a successfully rebuilt cities that were aided by the introduction of the LRT. However, it appears that there is a nation-wide plan to introduce these new modes of transportation. Motives for the introduction include the desire to control the city-sprawl effect and future financial crises that become inevitable due to the aging population. Additionally, there is also the desire to revitalize city-centers. In order to solve these problems, cities must be re-built to make a compact city. This is the reason LRTs and BRTs

are being chosen to be part of the transportation network.

The city of Toyama considered many opinions regarding methods that would effectively and efficiently use limited resources to fund the introduction of the LRT. The city created the "publicly constructed yet privately operated" concept, which called for a societal consensus to create a compact city that involved residents, businesses and the city government. At the same time, they received third party evaluations and developed a societal consensus.

The number of passengers increased to a level where the project had paid for itself. As a result of the LRTs, a modal shift from cars to public transportation was about 12 percent. Due to this shift, the amount of carbon dioxide reduced in the year 2006 was calculated at 436 tons. Examples such as this have become a model for other cities in Japan, and further introduction of the LRT is expected.

4-2 The direction of future technology based on societal needs

To support the "Innovation 25" strategy organized in 2007, the National Institute of Science and Technology Policy (NISTEP) put in place an expert panel to discuss the topic of "Safe and Sustainable Cities".[21] The panel discussed what a city in 2025 should look like, and proposed four measures to deal with societal concerns such as the following: increased seriousness of the environmental and energy crisis, ruined cities due to population decline and city-sprawl, increased car dependence and traffic accidents, and cities' weak responses to natural disasters. The proposed measures were: (1) Compact cities, (2) Environmentally-friendly urban transportation, (3) Distributed energy systems, and (4) Cities with few disasters.

The above concepts, together with what was discussed in section 4-1, formed the concept that calls for a public transportation system that is safe and environmentally friendly, while contributing to the development of compact and lively cities. Figure 15 outlines this concept. This chart shows the necessary functions and performance expectations in the future, and outlines the requirements for upcoming technologies and systems. The three requirements on future urban transport systems are as follows:

1)Ease of access and the ability to operate anywhere – even within public facilities.

This vision arises from the image that people should be able to easily access even old and confined areas of the city. These may include facilities vital for everyday needs such as roofed shopping areas and malls, government offices and hospitals. In order to achieve this, LRTs must be a compact vehicle and be able to operate without overhead wires. These are qualities that are within reach of today's technologies. Also, for example, Japan has been rapidly progressing in the research of batteries for electric cars. It would be optimal if we could use this technology for urban transport systems as well.

Assuming buses will be completely exhaust-free from since tests for electric buses are underway, it would be entirely possible to bring LRTs within the confines of public facilities such as shopping centers and hospitals.

In a country like Japan where seamless transfers between LRTs and existing train lines are not established, we should do away with ticketing gates and aim to build a technology that automatically charges passengers as they transfer. As a result, we can reduce unnecessary walking and make the transfer process friendlier for passengers, especially the elderly.

2)Service so frequent that there is no need to look at a timetable

This concept deals with how to maintain service frequency so that wait times do not become a problem. Dedicated tracks and roads will become necessary when it becomes clear that the concentration of traffic is causing traffic congestions. However, it appears that practical methods and know-how of traffic congestion management are not sufficiently established in Japan. This is because congestion-relief measures are not fully in place. Some ideas include traffic restrictions, congestion fees and usage limitations by time slot according to the purpose of the vehicle (deliveries, regular traffic, etc). In order to become less car-dependent, research and development must start in these areas.

It is important to note that simply increasing the

frequency of service would require extra costs, because naturally, the number of vehicles would have to be increased to achieve this. In order to prevent wasteful spending and promote efficient operations, we must consider the demand, calculate the best routing depending on the situation, and divide vehicles up accordingly. It is necessary to study this issue together with the aforementioned congestion-resolving measures. These research agendas are expected to become important in the future of R&D.

3)With no accidents, passengers can ride and live with a peace of mind

This concept comes from the ideal vision that pedestrians, cars and bicycles are not involved in accidents with urban transport systems. For this to become reality, there must be a high-precision sensing technology and cognitive systems that are able to detect people and objects. In the area of sensing technologies that identify obstacles (including people), significant development has been made in the car industry with Intelligent Transport Systems (ITS).[22] By adapting and integrating this into the area of urban transport systems, we can expect new technological developments for LRTs. There must also be information management technologies that determine risk from the information obtained through sensors that recognize the existence of people and vehicles. Furthermore, for human beings to process the information instantly and accurately, different approaches must be researched through brain science and bioscience.

By performing tests in areas where these transport systems have already been implemented, we can gather information regarding the future of these emerging technologies. We look forward to establishing an infrastructure where LRTs can communicate and coexist with pedestrians and other vehicles around them.

5 Conclusion

The technologies we discussed are largely separated into two categories. One category includes those technologies that are well underway in terms of development, and will be introduced to society in the near future. The other category includes those technologies that are still in its preliminary stage, or have not yet begun its testing stage. Technologies in both categories should eventually be implemented if we prioritize and determine the most efficient way to go about this process. For these new transport systems to become commonplace in society, there are several things that must be considered. One is the ease of transfer to and from other transportation systems, not just with railways, but also with cars and bicycles. Another is the simplification of the fare structure.

It is vital that we figure out a way to make the transition to these systems worthwhile in the eyes of society. If we further improve the technologies that make lives more convenient and increase

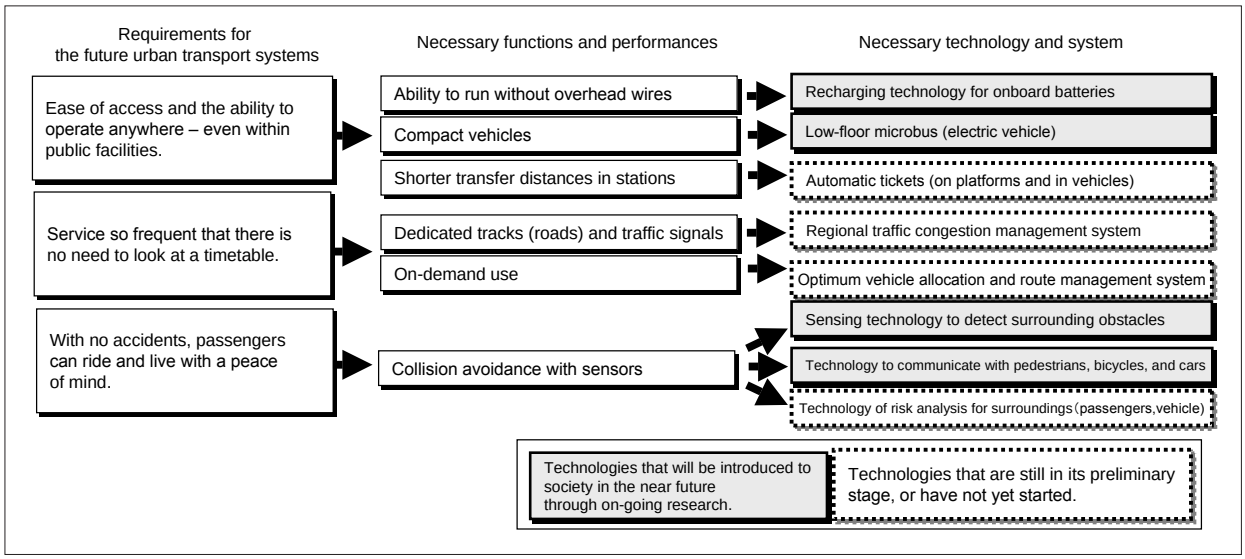


Figure 15 : Direction of technology and system required as future urban transport

Prepared by the STFC

societal benefits, we will be able to accelerate the modal shift toward public transportation and put an end to our car-dependent society.

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4

Ocean Science and Technology in the Starting Marine Management Era

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1 Introduction

The ocean has been used widely and freely for long time, though this idea has been reexamined and a new framework has been established to manage the ocean in recent years. Furthermore, the role of the ocean in regard to global environmental problems is beginning to be recognized. In Japan the Basic Ocean Law was established on July 20, 2007 in order to respond to this era of marine management. As a result the Basic Plan on Ocean Policy was established, based on the laws' basic way of thinking about the ocean: 'know', 'protect' and 'use', as an agenda of measures for the next five years, to ensure that measures concerning the ocean are implemented in a comprehensive and systematic manner. The policy aims of the plan are: (1) to be a pioneering challenge to the issues of the oceans that affect all of mankind, (2) to lay the foundations for the sustainable use of the oceans plentiful resources and space, and (3) to make a contribution in the oceanic field toward the realization of a safe and secure national lifestyle; and it also clearly shows a shift in the basis of the policy from a "use the ocean perspective" to a "governance stance". This Basic Plan on Ocean Policy was approved by cabinet on March 18, 2008, after Headquarters for Ocean Policy first compiled a draft version based on recommendations from various fields, then in February 2008 the opinions of a wide variety of citizens were surveyed to draw up the final version.

The Basic Plan on Ocean Policy attempts to uniformly promote Ocean Policy concerning Japans' Exclusive Economic Zone(EEZ).[*1] This is made up of 12 measures, including the following: (1) Aim to commercialize within the next 10 years the methane hydrate, which can be converted into natural gas, that has been discovered in marine area around Japan, (2) Double the number of Japanese registered vessels within 5 years in order to increase the international competitiveness of Japans' overseas shipping trade, (3) Improve laws to restrict unauthorized scientific surveys within Japans' EEZ by foreign vessels, (4) Consolidate the oceanic information from government agencies and independent organizations so that private enterprise and research institutes can make use of it.

This report gives an overview of the background and process involved in enacting the Basic Ocean Law and formulating the Basic Plan on Ocean Policy (Figure 1), and also sums up the issues and expectations of the future from a marine science and technology perspective.

Glossary

*1 **Exclusive Economic Zone (EEZ):**
Under the United Nations Convention on the Law of the Sea, it is a seazone over which a state has special economic rights over the exploration and use of marine resources. A state's EEZ extends to a distance of 200 nautical miles (about 370 km) out from its coast for special rights over the exploration, development and use of marine, minerals and energy resources, as well as for obligations of resource management and pollution control of the ocean. A 'territorial water' starts at the coastal baseline of a state and extends 12 nautical miles (about 22kms) for its special rights.

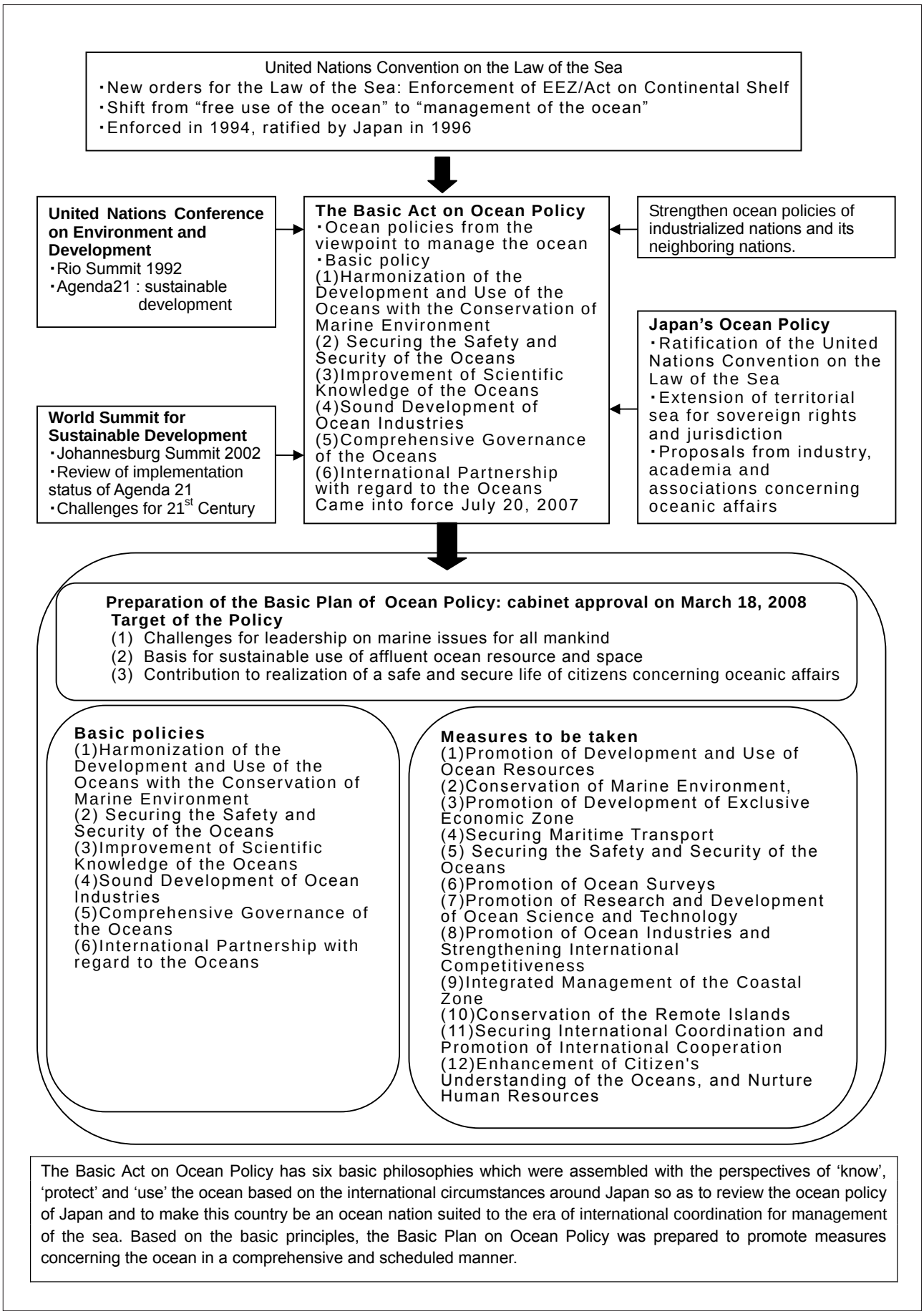

Figure 1 : Background and workflow: establishment of the basic ocean law and preparation of the basic plan of ocean policy for establishing ocean-based nation

Prepared by the STFC based on materials provided by Headquarters for Ocean Policy

2 Outline of the Formulation of the Basic Plan on Ocean Policy

2-1 Background of the enactment of the Basic Ocean Law

The oceans in the 20th Century were widely used and at the same time it was an era when there was intensified competition to obtain resources by the nautically advanced nations. With this as a background in the United Nations a rethink of the use and governance of the oceans upon the premise of 'small territorial waters' and 'expansive international waters' was underway, the United Nations Convention on the Law of the Sea (United Nations treaty regarding Maritime Law)[*2] was adopted in 1982, and came into force in 1994. Territorial waters were divided according to EEZ and continental shelf etc., international waters grew smaller, and furthermore the free use of international waters was restricted, the rights of coastal nations increased etc., and a new framework for International Oceanic Order was established. Also the role of the oceans in global environmental problems became recognized. The oceans are vast and have a purification capacity, and since the beginning of mankind has played a role in mitigating our environmental impact, however environmental problems affecting the ocean itself are becoming obvious.

In 1996, Japan ratified the United Nations Convention on the Law of the Sea, although efforts to compliment the International Oceanic Order are not progressing and even now are still in the pipeline. Japans' Ocean Policy is from the perspective of the users of the ocean regulating each user's stake amongst themselves, not from the perspective of regulating the way the ocean is used from a governance stance. Response toward marine minerals, energy resources and establishing the extent of the continental shelf has been put off.

Four reasons have been given for this. Keizo Takemi (at the time a member of the Upper House) made the following points during an FY2005 Activity Debriefing Session lecture at the Marine Technology Forum on July 26, 2006.[1]

1) Vertical administrative structure

Under a vertical administrative structure, Ocean Policy is under the control of various agencies: EEZ administration (Ministry of Foreign Affairs), protection of the marine environment (Ministry of the Environment), marine resource development (Ministry of Economy, trade and Industry), marine transportation and safety (Ministry of Land, Infrastructure and Transport), and marine science technology (Ministry of Education, Culture, Sports, Science and Technology), with no system established to decide on policy in a unified manner.

2) Lack of political leadership

While the oceanic problem was an important issue, there was no political leadership to overcome the evil of governments' vertical administrative structure, and a there was a lack of awareness of the problem involved in overall planning.

3) Putting off oceanic problems

The problems tended to be put off as there was concern that territorial disputes, fixing of EEZ borderline and securing oceanic rights within the EEZ, would aggravate sensitive problems with neighboring countries.

4) Low public interest in oceanic problems

With the world globalizing at an ever increasing pace, the people's interest in the oceans has decreased.

Glossary

*2 **United Nations Convention on the Law of the Sea (UNCLOS):**
It is the abbreviation of The United Nations Convention on the Law of the Sea, which was concluded in 1982 and came into force in 1994. The traditional international order of the sea, which maintained under the principles of 'Freedom of the Seas', was amended as a whole. It extended roles and responsibilities of coastal nations concerning development and management of the ocean, and introduced a new international policy for development and management of the sea by regarding the deep seabed and its resources as 'a common asset for mankind'.

The enactment of the Basic Ocean Law was considered, as in recent years interests in oceanic problems had once again risen, due to the emergence of issues over demarcation of the continental shelf[*3] and oceanic rights,[*4] as a backdrop to this. There were two streams of thought within this movement. One was from the perspective of 'securing oceanic rights within the EEZ'.[2] The demand that laws reflecting the ideals of ocean policy were necessary arose in the process of preparing draft laws from this perspective.[3] The other stream of thought was the report "Ocean and Japan: Proposal of ocean policy for the 21st century" submitted primarily by the Oceanic Policy Research Foundation in January 2006.[4]

The main contents of this "Proposal" were: deciding on ocean policy outline, enactment of the Basic Ocean Law, arrangement of administrative mechanisms such as the appointment of a Minister in charge of the oceans etc., governance of "Country" that encompasses the sea. It also stated that a General Symposium on Ocean Policy should be held in Cabinet, and that Japan, starting with the newly established ministry in charge of ocean policy, needs to lay out the framework for working on ocean policy. The following were anticipated with the enactment of the Basic Ocean Law:

1) To deal with strategic deficiencies of the entire policy, amend the non-functioning 'Liaison Conference for Concerned Ministries' to 'General Symposium on Ocean Policy' with more influence.

2) Regarding the problem of resource development within the EEZ, amend response so that the Ministry of Foreign Affairs and the Ministry of Economy, Trade and Industry cooperating in accordance with national interests.

3) Comprehensive measures, including taxation, be promptly implemented regarding the sharp decrease of Japanese registered vessels and Japanese crew, expeditiously.

Accordingly, the Basic Ocean Law was complied based on factors such as the above-mentioned changes in the international situation surrounding Japan and the proposal on Japans' ocean policy.

2-2 Philosophy of the Basic Ocean Law and objectives of the Basic Plan on Ocean Policy

The Basic Ocean Law was passed as legislation by house members in April 2007 and enforced on July 20 of the same year. Six basic philosophies are raised in this basic law, and these basic philosophies are also the ethos of the Basic Ocean Plan.[5] The outline of the basic plan's policy is

Glossary

*3 **Continental shelf demarcation disputes:**
A coastal state has rights to demarcate its continental shelf and develop living materials, minerals and energy resources within the shelf. Although the boundary may be extended beyond EEZ, rights for fishing resource in the water are not applicable to claim. 'A continental shelf' under UNCLOS is a legal notion of a district including the deep sea, which is different from a flat seabed to the geographical water depth of about 200m. UNCLOS Article 76 defines a continental slope as an "extent of underwater continental shelf of a coastal nation, which requires geographical data to identify the boundary. A coastal nation who wishes to extend the coastal shelf must submit a scientific data of the marine survey of the district and its claim to Commission on the Limits of the Continental Shelf (CLCS) of the United Nations. The commission will then evaluate the request and recommend identifying the limits of the continental shelf concerned. The deadline of the request is set as 2009.

*4 **Oceanic rights disputes:**
As EEZ is specified as 200 nautical miles from a coastal baseline, many disputes have risen concerning territories. There is even a case remain unsolved to identify an EEZ boundary between two nations. It also resulted in disputes concerning resource within an EEZ. Japan has currently have issues such as gas fields in areas of the East China Sea, territorial disputes on Takeshima, and the issue of Okinoshima (foreign marine research vessels conduct a research as EEZ cannot be defined for Okinoshima island).

summarized as follows:

(1) Harmonization of the development and use of the oceans with the conservation of marine environment

- As the coastal zone has various types of marine ecosystems and it is a highly utilized area, measures will be taken attaching importance to reducing environmental impact, and protection and renewal of the ecosystems.
- Due to Japan's has a expansive EEZ and continental shelf, and abundant offshore minerals, measures placing importance on there future development and utilization, and to enable this systematic surveys should be undertaken.
- It is necessary to clarify the governments role in the development of the untapped energy resources of the abyssal floor.

(2) Securing the safety and security of the oceans

- Strengthen systems, including the legal system, to ensure the security of the ocean with relation to marine transport and oceanic rights.
- Work on measures to protect people's lives and property from the threat of natural disasters originating at sea.

(3) Improvement of scientific knowledge on the oceans

- Oceanographic surveys for various administrative fields are carried out according to their purpose and the results are put to use in measures and policies. These kinds of oceanographic surveys maybe appropriate, however attempts at further improvement and adjustments to the system of operation are necessary in order to promote the further efficiency and data sharing of each survey.
- As there is still so much uncharted scientific territory in the oceans it is important to enhance basic knowledge and to pass on the benefits of survey and research results to society and the economy. Furthermore, it is important to secure and educate young talent, and to uniformly manage information on the ocean and maintain a system so that it is accessible.

(4) Healthy development of ocean industries

- It is necessary to maintain a competitive base by improving the system and maintaining competitive conditions in order for healthy development of ocean industry to occur.
- The creation of new industry that fully utilizes related technology, space and resources of the ocean should be pursued aggressively.

(5) Comprehensive governance of the oceans

- It is necessary to construct a system to comprehensively collect, maintain, and manage all of the information regarding the ocean immediately.
- Within the international community it is necessary to try to achieve peaceful, equitable yet sustainable development and use.
- As for the comprehensive governance of the littoral region, it is necessary to lecture on the measures needed reduce and mitigate the effects from continental areas.

(6) International partnership with regard to the oceans

- With regard to our surrounding ocean, Japan's rights need to be secured, order must be kept, and issue resolution according to international rules is required.
- With respect to the open seas around the world it is necessary for the development and formation of international order, and for Japan to play a leading role in this, in order to secure free and safe marine traffic, and to achieve sustainable use of fishery resources.
- Japan needs to play a leading role in international activities that contribute to global environmental issues as the part the ocean plays on the global environment is substantial.

These six basic philosophies were assembled with the perspectives of 'know', 'protect' and 'use' the ocean as a background. Here 'know' means to gather knowledge in order to appropriately use and conserve the largely mysterious ocean. 'Protect' means to care for the marine environment by using it in a sustainable manner, and also to ensure marine safety. 'Use' means to use and develop the ocean for growth of Japans' economic society

2-3 Formulation of the Basic Plan on Ocean Policy

The Basic Plan on Ocean Policy is based on the Basic Ocean Law's underlying philosophy, and was formulated with the aim of promoting policy relating to the ocean in a comprehensive and systematic manner. It was approved by cabinet on March 18, 2008. Being a medium term plan it will be reviewed approximately every five years according to the political situation and evaluation of measures. On July 20, 2007 cabinet established Headquarters for Ocean Policy with a mandate to promote ocean related measures in an intensive and comprehensive manner, based on the Basic Plan on Ocean Policy (Figure 2).

The goals that this plan, which covers the next five years, is aiming for are: to be a pioneering challenge to the issues of the oceans that affect all of mankind; to lay the foundations for the sustainable use of the oceans plentiful resources and space; and to make a contribution in the oceanic field toward the realization of a safe and secure national lifestyle.

The Basic Ocean Law states that the Basic Plan on Ocean Policy should establish, 'the fundamental objective of measures concerning the ocean' and 'government should take measures concerning the ocean in a comprehensive and systematic manner'. Regarding these measures the basic law establishes the 12 following items as the fundamental measures to be undertaken during the term of the plan. (1) Promotion of Development and Use of Ocean Resources, (2) Conservation of Marine Environment, etc., (3) Promotion of Development of Exclusive Economic Zone, etc., (4) Securing Maritime Transport, (5) Securing the Safety and Security of the Oceans, (6) Promotion of Ocean Surveys, (7) Promotion of Research and Development of Ocean Science and Technology, etc., (8) Promotion of Ocean Industries and Strengthening International Competitiveness, (9) Integrated Management of the Coastal Zone, (10) Conservation of the Remote Islands, etc., (11) Securing International Coordination and Promotion of International Cooperation, (12) Enhancement of Citizen's Understanding of the Oceans, and Nurture Human Resources.

In the process of formulating this basic plan proposals were submitted from various fields

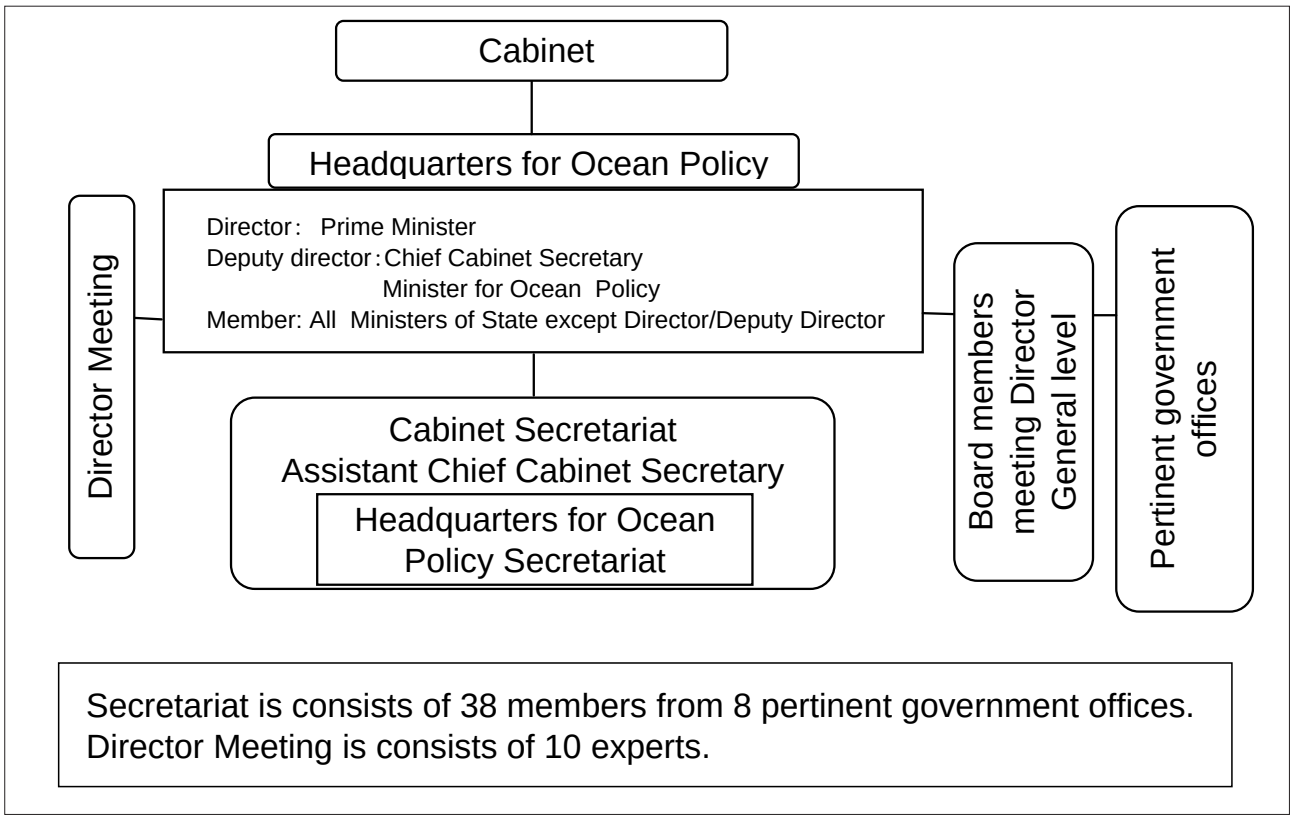

Figure 2 : Governmental organization promoting marine affairs under the Basic Ocean Law

Prepared by the STFC based on materials provided by Headquarters for Ocean Policy

such as the business community and academics concerned with the ocean. The following are the four main points:

1) University oceanographic researchers and ocean related academy proposed the need to build a network to share each field's information, to nurture human resources, to establish a foundation for oceanographic research, and to understand the fundamental biological, chemical and ecological processes involved in the oceans.[6-8]

2) The business community pointed out that the basic plan should not just gather together the measures promoted by each ministry and agency. Also it emphasized the necessity of promoting marine industry and strengthening international competitiveness, that as a national and international project, the comprehensive surveys and data of the ocean area under Japan's jurisdiction should be uniformly managed, bases on the ocean should be built and used as bases for the development of ocean resources etc., and should promote international partnerships and alliances. It also requested that in future there should be a system in place to reflect the ideas of the business community when developing measures, and furthermore the evil of ministries and agencies vertical administrative structure should be rejected and measures be developed in a top-down style.[9]

3) Academics involved with fisheries requested that the sustainable use of resources should be undertaken and that there be investment made into the fisheries industries.[10]

4) Wildlife protection organizations etc. proposed that the perspective of environmental protection should be included in the Basic Plan on Ocean Policy, as the Basic Ocean Law's main focus is on promoting the development of the oceans resources, however the Basic Ocean Law has an important role to play in protecting Japan's marine environment.

Since the Basic Ocean Law was enacted, the first draft of the Basic Plan on Ocean Policy has been assembled based on the three General Symposiums on Ocean Policy, the aforementioned proposals from various fields, and the opinions from the three Participation Conferences. The Basic Plan on Ocean Policy gained cabinet approval after the final plan was drawn up based on the comments on the first draft from many members of the public.

3 Ocean research and the Basic Plan on Ocean Policy

The development of oceanographic scientific technological research comes under 'enhancement of scientific knowledge' in the Basic Plan on Ocean Policy. I would like to point out the issues for the future, even though all of the important keywords have already been covered.

3-1 Connected to the world through ocean

Japan is a 'maritime state' surrounded on four sides by the ocean. However, there is a great difference between whether the ocean is seen as a protective barrier of this island nation or an open path through which to exchange with the world. In Japan, we have been brought up with a strong consciousness that the ocean has protected us from other countries. This is epitomized in the word 'protect', one of the basic philosophies of the Basic Plan on Ocean Policy. Of course to 'protect' is very important, it is more important to connect with the many countries of the world via the ocean, and the main focus of the Basic Plan on Ocean Policy's 'international cooperation related to the ocean' should be to 'connect' with the world.

The vested interests with countries that we are connected to by the ocean are complicated and diverse. In order for there to be free and safe navigation, and to realize the sustainable use of the oceans fishery resources, Japan needs to play a leading role in establishing international order. Furthermore, the area of scientific surveys should not be restricted to EEZ under Japan's jurisdiction, but should cover the entire ocean on earth. Permission is necessary in order to carry out a research survey within another countries' EEZ, and in some cases permission is not given. For this level of international regulation, it is necessary for national bodies to assimilate responsibility for putting together rules, regarding scientific surveys

of the ocean, at a national level, as it is difficult with only the processing application of various research bodies.

On the other hand, the possibility of artic ice cap disappearing as a result of global warming is being debated. For surrounding coastal states this opens up the possibility of exploiting the vast resources that lie untouched on the arctic seabed, and also to the possibility of a revolution in world cargo shipment if these shipping routes are opened up. However, it is also clear that if the arctic ice caps disappear there will be dramatic changes to the ocean current circulation and heat circulation on a global scale. Therefore, this is not just a problem concerning coastal states surrounding the arctic, but concerns all of mankind. This kind of phenomenon should not be just unraveled by scientists research, Japan needs to decide the necessary role to take toward the arctic problem, and what kind of specific survey research to position itself.

In the research and development of the marine environment relations with neighboring countries are especially important. The problem of garbage floating and coming ashore from ocean currents comes under one of the policies in the Basic Plan on Ocean Policy, 'comprehensive management of the ocean', with all encompassing measures, including those at the source, being necessary. While it goes without saying that measures to stop the dumping of garbage into the ocean in Japan are necessary, at the same time the promotion of friendly and cooperative environmental initiatives with neighboring countries are also necessary. It is important for international cooperation where roles are shared and jointly developing ocean scientific technologies etc. with neighboring countries. The present situation is of exchange only on a small scale amongst scientists. For example, if there happened to be an oil spill or another kind of major marine environmental pollution, international partnerships and cooperation are necessary, because even if each country keeps developing technology on a small scale to deal with accidents that happen rarely but have enormous consequences, the research and development is inefficient, and it is difficult to maintain and develop these technologies.

In order to solve such problems it is expected that the Ocean Policy Headquarters take the initiative in developing Japan's overall ocean policy, and the promotion of measures that the Oceanic Research and Development Organization etc. can positively cooperate for the development of marine science technology of countries concerned.

3-2 Ocean science research fields that should be promoted

The importance of to 'know' the ocean is expressed in the Basic Ocean Law, from the perspective of managing the ocean, and for the purpose of realizing of a safe and secure national lifestyle. Article 4 of the Basic Law states the idea of enhancing scientific knowledge of the oceans, and it is clearly described in Article 22 to the need to promote oceanographic surveys, and in Article 23, the promotion of the research and development concerning the marine science technology.

Japan is an island nation positioned between vast Eurasian continent and the Pacific Ocean where the earth's crust is extremely active. It is an island arc, seismically and volcanically very active, formed by various oceanic plates sinking beneath the continental plate. Moreover, a surrounding sea is widely varied from shallow waters to deep ocean abysses. Japan is also blessed with abundant ecosystems, and extremes in climate and weather, as a result of its location in the west Pacific where the cold Oyashio (or Kurile) current from the Northeast and the warm Kuroshio (or Black) current from the southwest collide. Therefore, the research related to the ocean in Japan covers a wide variety of disciplines, from research to understand the global environment, to research into the utilization of resources. The following areas of marine science research should be especially advanced in the future (Figure 3).

(1) Research of sea floor dynamics

On the human time scale the earth is almost completely solid, at the most we get to see volcanic eruptions or earthquakes etc., but on the earths time scale in the millions of years, it changes extremely actively, what was once the bottom of the ocean can become the worlds highest mountain, and material from the earth' that spew from fissures in the ocean floor gets carried like on a conveyer belt under the continental crust. It is not possible to understand oceanic type of

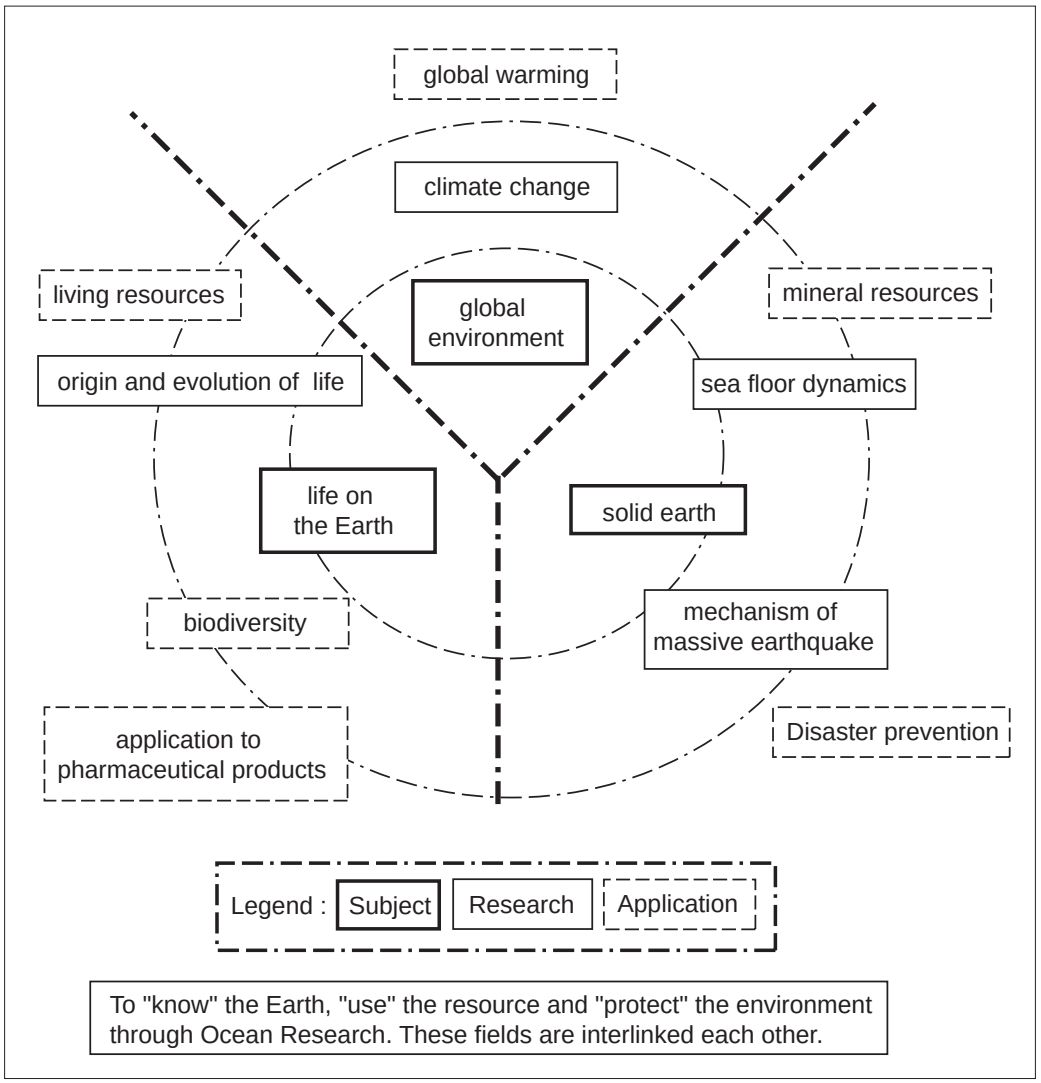

Figure 3 : Fields of subject/research/application on ocean science

Prepared by the STFC

seismic or volcanic activity in Japan without such research into the dynamics of the ocean floor. Such research provides fundamental knowledge for the exploration and the use of offshore mineral and the energy resources.

(2) Oceanic research related to climate change

On earth the energy from the sun is absorbed in low latitude areas and released from areas of high latitude, and heat is carried by seawater and in the atmosphere from areas of low latitude to higher latitude. At present the earth's climate is balanced by moving such energy in the existing state of things. Changes are occurring in a variety of time and spatial scales, heat is exchanged between the atmosphere and the ocean and as a result the atmosphere moves to create wind, seawater moves to become ocean currents. However, as a result on human-induced global warming these variation patterns are starting to change drastically. The Fourth IPCC (Intergovernmental Panel on Climate Change) Assessment Report published in 2007 concludes that global warming is progressing due to an increase in levels of greenhouse gases in the atmosphere. It is feared that most of the heat increase due to global warming will be absorbed by the oceans, and if the water temperature of the oceans surface layer increases, this will impede the mixing of the oceans surface and deep layers, which in turn will adversely affect the circulation of materials and ecosystems. Also, it has been observed in the Arctic Sea that sea ice is decreasing quite rapidly.

An accurate and long term prediction study that is based on wide-ranging, exact and exhaustive observations is indispensable to knowing what kind

of scale and time the various changes in the ocean progress at. Even though the research on these problems should be promoted by the international cooperation of every country in the world, Japan should take an active, if not leading, part in promoting them.

(3) Research on evolution, and the origin of biodiversity and life

The oceans are affected in various was by climate change. Not only does the flow of heat and material in the atmosphere and ocean change, but so does the activity of marine organisms. It is feared that the ocean's ecosystems will change and biodiversity decline, atmospheric CO_2 mixing in seawater will acidify the ocean, and that husked animals will become extinct. How these will influence climate change has become a research topic for the future.

In the past, it was believed that marine organisms only inhabited the very surface and coastal areas. In the last quarter of a century, with the development of deep sea scientific technology and the accumulation of scientific knowledge, scientific concepts concerning marine organisms were transformed greatly. Various biotic communities were discovered in the intermediary and deep layers of the ocean. Organisms that chemically synthesize, which is completely different from photosynthesis on land and the oceans surface layer, were discovered. It is now understood that these form the basis of an ecosystem. In addition, it has been understood that communities of microorganisms live in the deep subsurface under the ocean floor in recent years. Such research is having a big influence on the scientific concepts of evolution of species and the origin of life, and further development is expected in the future with innovations in observatory technology.

3-3 Necessary infrastructure for oceanographic research

The Basic Plan on Ocean Policy describes the current state of affairs, "ships and equipment with state-of-the-art performance are necessary in order to advance marine surveys in world leading manner, however, in addition to the aging of existing ships and equipment, the effect of recent high oil prices are causing survey activities to be restricted in part". The following measures are seen as necessary in order to improve on this current state of affairs: "promote operational efficiency and sharing of information on survey plans etc.", "Respond flexibly to the state of fuel prices etc. and in a calculated manner with respect to the maintenance and operations of facilities and equipment etc.", and also "specific marine surveys for the necessary fundamental information for ocean governance should be carried out with cooperation and partnerships between each organization".

Up to now, various organizations involved in the above mentioned situation have each put in a lot of efforts. The problem from herein is setting a standard on what kind of process the renewal maintenance of the aging facilities and equipment should be taken. Headquarters on Ocean Policy needs to set a definite standard, and not just leave to the discretion and effort of various organizations alone, when dealing with the lifespan of structural strength and becoming obsolete as a research facility, and not having made a specialist ship such as an oceanographic research vessel for a long time is a problem, also from the viewpoint of technological succession. In recent years, the Antarctic Observation vessel 'Shirase' was given 4 years of service life extension repairs after the standard commission period of 20 years, and was fully retired in the fiscal year 2007. It was decommissioned according to the rules regarding escort vessels despite the opinion of researchers who said its service life should be extended to fill the 1 year blank until the new Antarctic Observation vessel comes into operation. It is not acceptable if Headquarters for Ocean Policy cannot recommend corrections to each agency or ministry to update necessary rule changes, in order to eliminate vagueness of the operation period etc., and to maintain and develop up-to-date performance.

Recently, the repercussions of the sudden rise in fuel costs are enormous. There is a limit to the effort that each organization can make to operate ships and equipment efficiently. There is a problem when something that took an enormous expense to develop is lying idle. It would be more effective if Headquarters for Ocean Policy solely handled the operation costs with the financial authorities,

and a need for flexibility in operations between institutions, in order that the ships and facilities can be operated as effectively and efficiently as possible.

Two common fundamental problems in maintaining a research platform are: the necessity to, not only enhance hardware, but to train personnel to operate and work that hardware to ensure skills are passed down, and to train personnel in service industries. Enhanced hardware becomes a useless possession if there is no one capable of operating it to acquire high quality data. Of course each institute is responsible for training personnel in charge of observatory surveys, however Headquarters for Ocean Policy should have the authority to recommend that it be their duty to carry this out, and the authority to make corrections and adjust budget measures when found to be inappropriate. It should be necessary for Headquarters for Ocean Policy to show a national strategy regarding personnel training and passing down skills in the oceanic field.

It is a fact that Japan relies on imports for all but a small portion of the measurement equipment used in oceanographic observation. It is unavoidable that a large part of the oceanographic survey research expenses are spent on purchasing equipment from overseas, as there are no makers of precision measurement equipment in Japan at present. It could be said that it is a serious situation not to be able to carry out survey research independently for the foreseeable future, even though this may be useful in terms of exchange with other countries. The problem is thought to be that there is no incentive for the engineers to develop measurement equipment. It is hoped that a fund would be established to encourage the research and development of measurement equipment, as well as to promote the measurement equipment industry.

A system needs to be developed by Headquarters for Ocean Policy that places high value on development systems that lead to innovation and next generation technologies.

3-4 Top-down leadership expected to the Headquarters for Ocean Policy

Specific problems regarding Headquarters for Ocean Policy's expected role in advancing oceanic research have been discussed above. The structural role expected of Headquarters for Ocean Policy is examined here. Basically, it should show a in a top-down manner the marine science technological measures that need to be advanced as part of a national strategy, and the ocean policy that each agency and ministry independently promotes should be based on this. I would like for Headquarters for Ocean Policy to play a role in strongly promoting the specification of strategic targets (Figure 4).

Japan has numerous Basic Laws, but besides from the Basic Ocean Law, there is the Environment Basic Law administered by the Ministry of the Environment, the Basic Law on Fisheries administered by the Fishery Agency, and the Basic Law on Energy Policy administered by the Agency of Natural Resources and Energy. The ocean policies that each agency and ministry administer have been implemented based on these Basic Laws. It is hoped that the newly enacted Basic Ocean Law, which is administered by the Cabinet Secretary with the Transport Minister serving as the Ocean Policy Minister concurrently, will integrate the policies based on each agency and ministry and their respective Basic Laws.

With regard to the research and development of scientific technology, the "Science and Technology Basic Plan" was formulated based on Science and Technology Basic Law regulations, and the General Council on Science and Technologies report. The General Council on Science and Technology plays the role of 'control tower' with respect to the promotion of this plan. In the 3rd Science and Technology Basic Plan (2006 – 2010) it states that "science and technology is the tractor for society's sustainable development" will be the "power to open up the future of humanity", and deals with the various problems that the human race will face in the 21st Century. 'Environment' is one of the plan's four fields for priority promotion, 'Ocean' is located in 'frontier', another of the four fields for priority promotion, and also the issue of marine science technology strategically promoted as a key national technology.

In the future, the research and development of marine science technology will be concerned with both the Basic Ocean Law and the Science and Technology Basic Law. At present, it remains

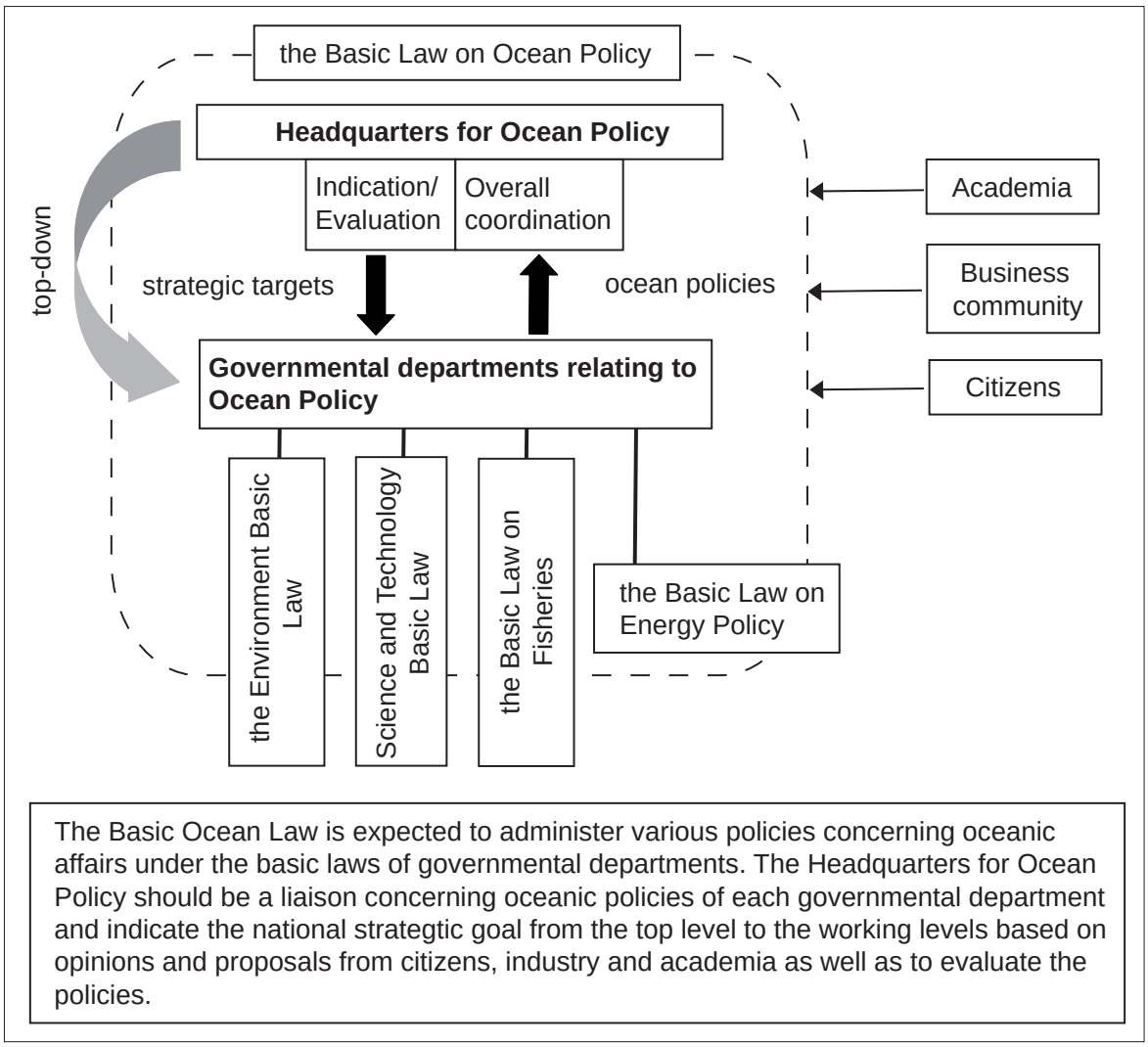

Figure 4 : Top-down mechanism expected to the Headquarters for Ocean Policy

Prepared by the STFC

unclear whether the 'information' in "unified management and provision of information concerning the ocean", toward which the Basic Plan on Ocean Policy is aiming, refers to only the data from government research bodies, or if it includes data from research institutes also. The Basic Plan on Ocean Policy manifests the type of oceanographic data vital to Japan, and calls for a unified method of its acquisition and use. Moreover, it is likely there will need to be additional budgetary allocations to the research and development institutes in order that they can develop technology to make possible the acquisition and use of such data.

4 Conclusion

Various opinions and concepts were submitted from the business world and the scientific community during the formulation of the Basic Plan on Ocean Policy, with the enactment of the Basic Ocean Law acting as a catalyst. Implementing the plans instituted by the Basic Plan on Ocean Policy will lead to the future of Japans oceanographic research and development, and is vital also to the invigoration of the research community. On the one hand it is not easy to achieve oceanic development, as there are so many fields related to this, and the initial investment costs are so high, however in future, it is hoped that with the implementation of the Basic Plan on Ocean Policy there will be steady progress of the

planned framework.

'Ocean', which is the subject of the Basic Plan on Ocean Policy, is not necessarily limited to EEZ and the continental shelf. It is also related to the global environment and the International Law of the Sea, and it is important to approach the ocean from a global perspective. However in the Basic Plan on Ocean Policy 'ocean' means, that area which is under Japans administration and management, and that area is limited. That being the case then, for example, it is warned that due to global warming the arctic sea-ice may melt, however in Japan there may be no Ocean Science Technology Policy proposals toward such a problem of global scale.

Moreover, only with actual and sustained development of: scientific research activities in Japan's EEZ and continental shelf, scientific research and observation, environmental planning, resource inquiry and development, and industrial use, etc.; can Japan secure its oceanic rights and interests. Promising deposits, such as iron ore deposits around deep sea thermal vents and cobalt rich crust etc., exist on the seabed within Japan's EEZ and continental. On the other hand, fisheries are a renewable resource, so it is important to use them in a sustainable manner. In addition, the ocean has the capability to buffer the global environment. International cooperation and partnerships are required in order to further our knowledge on these subjects. In order that these be accomplished simultaneously, it is necessary for Japan to develop marine science technology so that it becomes a world leader in both the 'hard-side' (as in the actual technology), and the 'soft-side' (being the human-side of the research and development etc.).

Very noble ideals are expressed in the Basic Ocean Law, however, the actual ocean measures and policy demands will be carried out by each ministry and agency. Moreover, for the foreseeable future, budget increases for overall oceanic policy cannot be expected, and it is probably impossible for any measures that are not in the Basic Plan on Ocean Policy to be carried out. Furthermore, it seems that the Ocean Policy, which until now has been promoted within each ministry and agency, will be in for even severer competition. Very strong top-down leadership, based on the ideals of the Basic Ocean Law, is required of the General Headquarters on Ocean Policy, in order that there be an integrated approach to the promotion of measures.

Up until now, amongst many of the people working in connection with research and development etc. in the oceanic science and technology field, there has been a feeling of almost resignation that, "no strategic ocean policy gets conceived because no Basic Ocean Law exists". Just because the Basic Act on Ocean Policy and the Basic Plan on Ocean Policy have been passed in cabinet is not to say that immediately all kinds of problems will be solved, however at the least it can be said that now, not only individuals concerned with the ocean but all of Japans citizens are standing at a common starting point. It is hoped that the General Headquarters on Ocean Policy shows top-down leadership in advancing Japans' oceanic strategy, by becoming a coordination institute with respect to each oceanic measure that the various agencies and ministries are responsible for implementing in future, and also shows this kind of leadership toward the policy issues that need to be promoted as National Basic Policies. It is also hoped when the General Headquarters on Ocean Policy is promoting the Basic Plan on Ocean Policy, it does not restrict 'Ocean' to mean only the EEZ etc. under Japans sovereignty, thinks of the entire earths oceans, and can widely 'connect' with the countries of the world through international cooperation. On top of that it is hoped that Japan's Policy on Marine Science Technology becomes a model for the world.

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5

Initiatives for Innovation Measurement by the US Department of Commerce (DOC)

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3rd Policy-oriented Research Group

1 Introduction

On January 18, 2008, the United States Commerce Secretary Gutierrez called for action on innovation measurement based on the report entitled "Innovation Measurement, Tracking the State of Innovation in the American Economy" by the Advisory Committee on Measuring Innovation in the 21st Century Economy.[1] This initiative has a couple of features; (1) The investigation was pursued under the government's recognition that innovation is an economic driving force. It would be necessary for policy makers and the people to understand the impact innovation has on productivity and economic growth,[2] in order to apply appropriate policies. (2) The committee members, selected from the top down, included influential business leaders, as well as eminent researchers. (3) Actions not only by the DOC, but also by cross-government, private sector, and academic circles are required.

In Japan's "3rd Science and Technology Basic Plan", creating innovation is listed as one of the major direction of science and technology policy. Innovation based on science and technology is regarded as an important measure to bring the benefit of research and development to the society and its citizens."The Comprehensive Strategy for Creating Innovation", based on the plan, suggested to measure the effects of innovation, and then reflect the results in policy planning and evaluation.

Therefore, it can be said that the above mentioned cross-ministerial initiative to measure the effects of innovation and reflect the results in policies, is a big hint for our country. In this report, the innovation policies and measurement trends up to the DOC report and the report itself will be outlined from such a viewpoint.

2 Trends of innovation policy and innovation measurement [3]

In recent years, as globalization of business and the rise of emerging economies such as the BRICs, have been intensifying international competition, countries like the US, European nations, and Japan have focused their policy more on innovation: The movement to seek after the sources of economic growth and competitiveness in innovation, and to take the strategy to promote innovation.

In the US, "Innovate America" (a.k.a. Palmisano Report), "Rising Above the Gathering Storm" (The National Science Academy Report), "The National Competitiveness Initiative", and the "America COMPETES Act" (The US Competitiveness Act) which was enacted in August of 2007 are named as recent policies. In Europe, "Lisbon" and "New Lisbon Strategy", In Japan "the 3rd Science and Technology Basic Plan", "Comprehensive Strategy for Creating Innovation", "Innovation 25", "the Revolutionary Technology Strategy," and "the law to strengthen R&D power" are named respectively.

Along with these, the movements to measure the effects of innovation policies and innovation itself for the benefit of policy formulation and implementation have increased. In the field of science and technology index, development has been advanced by groups like the National Science Foundation (NSF) and the Organization for Economic Cooperation and Development (OECD). In Japan, National Institute of Science and Technology Policy (NISTEP) has compiled similar indicators. On the other hand, the OECD has made public the "Oslo manual", a manual for collecting and interpreting data about innovation activities by business. Based on this manual, four "European

Innovation Surveys" have been carried out.

Recently in the US, however, frustrating with static indices so far, even larger initiatives for measuring innovation are in progress in order to formulate and implement science, technology, and innovation policies timely, based on evidences which describe the dynamism of a fast changing business society. The NSF's "Science of Science and Innovation Policy (SciSIP)[NOTE]", based on the advocacy of the current Science Advisor to the President, Dr. John Marburger III, and the "Innovation Measurement" by the DOC.

3 The advisory committee concerning innovation measurement in the United States

Among the two above-mentioned initiatives of the United States, the DOC's initiative on the measurement of innovation has been advanced under the following recognition:

(1) Innovation is important for the vitality of the US economy, and it is important to understand the impact that the innovation has on productivity and economic growth.
(2) Understanding how innovation contributes to economy will greatly contribute to formulating policies for long lasting growth and prosperity.

On August 4, 2006, Secretary of Commerce Gutierrez announced the establishment of the "The Measuring Innovation in the 21st Century Economy Advisory Committee", and a task force within the ministry to deal with the committee. This advisory committee consists of the chairman Carl Schram (President and CEO of Ewing-Marion-Kaufman Foundation), and 15 industry leaders and eminent researchers such as Samuel Palmisano(Chairman, President and CEO of IBM), Steve Ballmer (CEO of Microsoft), George Buckley (CEO of 3M), and Professor D.W. Jorgensen (Harvard University). The committee began meeting from February of 2007, and on January 18, 2008, publicized its final report, "Innovation Measurement, Tracking the State of Innovation in the American Economy".

4 The report "Innovation Measurement, Tracking the State of Innovation in the American Economy"

In the report, the advisory committee first defined innovation as follows:

[What is innovation?]

[Innovation is] *the design, invention, development and/or implementation of new or altered products, services, processes, systems, organizational structures, or business models for the purpose of creating new value for customers and financial returns for the firm.*

The point to which we have to pay attention here is that the initiative has a perspective wider

[NOTE]
"Science of Science and Innovation Policy" (SciSIP):
Examples of the action taken in the NSF's SciSIP program
(1) Workshops for making the framework of the SciSIP
(2) Competitive funding for research on science, technology and innovation (the theoretical and conceptual modeling of innovations based on science and technology, development of econometric tools for measuring the effects of investment in science and technology, development of a qualitative evaluation tool, and development of bibliometrical analysis tool)
(3) Development of science, technology and innovation related data (data on R&D and innovation both at firm and business level, data on R&D fund sources and innovation activities, related human resource data, measurements of intangibles, and data relating to the social effects of science, technology and innovation)
(4) "Collaboratories": establishing infrastructure for collecting data and analyzing them using innovation model by combining methods of information science such as data mining and supercomputers, while gather researchers from various study areas
(http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=501084&org=SBE&sel_org=SBE&from=fund)

than “technological innovation”, through which processes, products, or services are improved or newly created based on science and technology. By “innovation” the initiative looks whole activities that bring new values to the society, which also includes novel system, organization, and business models.

Then, the advisory committee carried out examination from the stand point that that it is necessary to pursue not only the input of the innovation that has been measured so far, but also the result of the innovation (outcome), in measuring economic effects of the innovation.

The report, which was organized taking into consideration such things, first states six guiding principles for innovation measurement including: ① Data on innovations should be collected in line with the way private firms do in evaluating the effect of their innovation activity, ② Effects of regulation should be considered, ③ Innovation data should be able to be analyzed at establishment, firms, industry, national, international, and possibly at local level. Te recommendations follows are: “What the government should do for innovation measurement”, “How the industries can contribute to innovation measurement”, and “The research necessary in innovation measurements”. Also at the last, it is stated that “implementing the recommendation will greatly contribute to the effective measuring of the impact innovation has on our country and is necessary for understanding innovation and formulating better policy. The committee asks for the government, industries, and researchers to work together, for better understanding and measurement of innovation”.

4-1 What the government should do for innovation measurement

The report calls for the government: to coordinate emphasis on measuring innovation, to improve data structures of existing government statistics, to collect newer and better data, to improve the linkage among government’s administrative statistics, and to share and synchronize their data. A focal matter the government is assumed to work on, especially, is the “construction of a stronger framework for the specification and measurement of innovation in the national economy”, and concretely recommends the following.

(1) [Developing the measurement of annual total factor productivity at industrial level.] Combining the NIPAs (National Income and Product Accounts) with other government statistical data, in order to re-construct a more synchronized accounts, and this will allow for consistent estimation on the role innovation plays in economic growth.
(2) [Establishing an innovation supplemental account in NIPAs] To make it possible to follow the flow of input factors among industries, by adding input factors of innovation in the account.
(3) [Improvement of data concerning the service industry]
(4) [Improvement of measurements of intangibles]

Besides, the report names the following points to be done by the government: utilize more existing government statistics data, improve access to data for research, promote innovation through forums or workshops by the DOC, examine obstacles and realization factors, secure as much international comparability of US measures as possible by consistently participating in international discussion on innovation measurement and analysis, and examine the development of a national innovation index which takes into consideration the factors and analysis process of later data collection. Finally, the report requests to allocate budget necessary for the implementation of these recommendations.

4-2 How the industry can contribute to innovation measurement

Regarding the contribution of industries, the report states that innovation should be measured through cooperative process with industries, and it is possible for industries to contribute to the improvement of innovation measurement in various ways, and thus, promote the measurement.

Then, the report calls for firms and industries to create, enlarge, and then implement innovation indexes, as well as developing a best practice of innovation measurement and participating in innovation research for the improvement innovation measurement. The report also asks industries, if needed, to supply researchers with innovation-related information.

4-3 Where research is necessary in measuring innovation

Although understandings on innovation deepened recently, the report states, much more research on innovation and its measurement is needed. Governments, businesses, and academia are asked to commence with further more research. The following research fields, especially, are asked to be tackled:

(1) [Innovation outcome measurement] The assessment of the effectiveness of the innovation measurement based on market share, the development of innovative intensity measures by reviewing the experience of other countries and the implementation of a pilot project, and analyzing qualitative and quantitative impacts of obstacles and realization factors.

(2) [Identifying and obtaining the insufficiencies in innovation data] The identification of data which is effective in innovation measurement, the possibility of utilizing transactions of intellectual property, and the measures for identifying intangible investments.

(3) [Analysis of the relationships between innovation activities and cooperation, innovation performance, and enterprise performance] The analysis of the relationships between innovation and employment, innovation intensity and enterprise performance, and cooperative relationships of enterprises and innovation outcomes; The comparison of international innovation activities of enterprises; The identification of innovative practices and enterprises by analyzing enterprise data; Analysis of the relationship between business dynamics and innovation based on long-term data; and The comparison of innovative performance of enterprises in different regulated environments.

5 Conclusion

Among the two new initiatives, the NSF's SciSIP, which has based on the advocacy by Dr. Marburger, and the innovation measurement by the US DOC, the latter initiative on improving economic statistics and measurement has reported so far. To conclude this report, I would like to mention the relationship between these two sides.

On the contrast to the DOC's initiative, the SciSP of the NSF has contributed to innovation measurement mainly from research side. Workshops has held and research grants have already solicited proposals twice.[4] The NSF, which especially is expected to develop the research and development index, is planning to reflect the results from SciSP in "Science Engineering Indicators", in 2010.[5] In addition, in the case of the measurement of intangibles, which is a pillar of innovation measurement, the DOC has already implemented the preliminary estimation of the "Research Development Satellite Account" in collaboration with the NSF. In the autumn of 2007, they reported that the "it is estimated that the GDP has annually increased by about 3% from 1959 to 2004, if you treat R&D cost as intangible investments".[6]

The two initiatives, the NSF and the DOC, have worked under a common purpose to show the economic effects of innovation and contribute to future policy planning. They have been moved forward under cooperation and role-sharing: the development of science and Engineering Indicators and funding for related research by the NSF, and the development and measurement of economic statistics by the DOC. We have to continuously pay attention to these trends and progress as an example of an inter-ministerial cooperative approach for innovation measurement.

[Attached document]

"Innovation Measurement, Tracking the State of Innovation in the American Economy"

Table of contents and outline

Summary

[A message from the chair – Why measuring innovation matters]

There are four challenges to innovation. The first is the understanding of the relationship between economic growth and innovation, and the second is the definition of innovation itself. The third challenge, and the main focus of this report, is the measurement of innovation, and this is the most important realistic challenge.

Innovation cannot be represented by just one index, and a framework for indexes is needed. The last challenge is how you make innovation happen, and how you continuously raise it. To maintain a strong economy, it is necessary to improve innovation measurement, and enhance innovation skills.

Chapter 1: The current state of innovation measurement and setting up an advisory committee

○The current state of innovation measurement

Innovation measurement is still in its early stages. National bodies and public enterprises have collected data, but they are not yet sufficient. The Department of Commerce's Bureau of Economic Analysis, the Internal Revenue Service, and the US Stock and Exchange Commission have begun to plan the expansion of data. In the EU, wider information on innovation has been collected through innovation survey, but it is still at an insufficient state.

○Setting up an advisory committee

The advisory committee defined innovation as the design, invention, development, and/or the implementation of new and improved products, services, processes, systems, organizational structures, or business models, with the goal to create profit for enterprises and new value for customers. The committee drew up recommendations based on the current status of data collection. In addition, as there is currently limited knowledge of innovation, it is impossible to make a recommendation only on one measurement process, and therefore many processes are suggested.

Chapter 2: Guiding principles for innovation measurement

The final goal of the recommendations is the development of measurements for innovation and its effects on the economy, in other words, the estimation of inputs and value added. Currently, data collection for innovation measurement has not been done, and the existing data is fragmented. There is a need for governments, private enterprises, and researchers to collaborate and deepen their understanding of innovation measurement. When going forward with such activities, the following principles should be noted:

-Data collection should be done in line with the enterprises' own innovation evaluation method.
-The effect of laws and regulation have on innovation should be taken into consideration.
-Qualitative and subjective measurements are acceptable
-Innovation Measurement is continuously improved, and never in a fixed state.
-It should be able to be broken down into each level of group, enterprise, industry, regional, country, and international.
-When collecting new data, the trade-off between the cost and the return, the resources

available for collecting data and regulations should be taken into consideration.

Chapter 3: What the government needs to do

(1) The establishment of a stronger framework for the specification and measurement of innovation in the national economy

-Reorganizing the NIPAs (National Income and Product Accounts) and developing the measurement of annual total factor productivity at industrial level (by combining the labor statistics with NIPAs)
-Create a supplemental innovation account (including R&D human resources, and intellectual property)
-Improvement of data concerning the service industry
-Improvement of measurements of intangibles, especially, intellectual property rights

(2) Besides this, the government should continually utilize existing government statistical data to promote the understanding of innovation and the possibility of a consistent estimate of innovation in GDP and growth accounts.

-Find relationships in existing data.
-Develop a more robust categorization method (categories of industries for domestic and foreign enterprises)
-Legal regulations for synchronizing and sharing data among government agencies

(3) Increasing data access

-Securing more access counts and clarity by tagging data.
-Creating a public file for promoting non-governmental research.
-Expanding access to classified data.

(4) Hold workshops and discuss about the promoters and obstacles of innovation.

(5) Secure an international harmonization by participating in international discussion on innovation measurement and analysis.

(6) Develop a national innovation index by data collection and analysis of promotional factor.

(7) Raise funding to implement the above recommendations.

Chapter 4: How the industries can contribute

(1) Implementing innovation measures at industrial and enterprise levels
-Set up an enterprise-level innovation measurement, and then compare it with existing methods.
-Measure the performance impacts and innovation within the enterprise.
-Develop the best practice for managing and measuring innovation.

(2)Participating in research activities, and supplying information to researchers.
-Participate in collaborative projects, to collect wide-range data.
-Publicize data using the XBRL format.

Chapter 5: Areas where research is necessary.

(1)Setting up an innovation outcome measurement methods and evaluating them

-Evaluating the feasibility and effectiveness measurement based on market share
-Evaluating the feasibility of innovation measurement intensity (commencing with foreign studies or pilot projects)
-Qualitative and quantitative analysis of the effects of promoters and obstacles of the innovation

(2) Identifying and obtaining the insufficiencies in innovation data

-Identifying data applicable to innovation measurement
-Evaluating the feasibility of collecting data on intellectual property transfers
-Performance evaluation of highly innovative enterprises
-Evaluating the effect of collaboration and the main reason to collaborate.
-Evaluating international innovation activities
-Identifying innovative enterprises by analyzing public data
-Analyzing the relationship between innovation and business dynamics by utilizing long-term data
-Analyzing the relationship between innovative performance and regulation environments.

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Report on the annual AAAS Forum on Science and Technology Policy

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1 Introduction

From 8th to 9th of May 2008, the AAAS[NOTE1] (American Association for the Advancement of Science) held the Forum on Science and Technology Policy in Washington D.C. The forum aims to provide interested persons the opportunity to understand and discuss priority issues facing the U.S. community of science, technology and higher education. Participants in the forum are scientists, engineers, policy makers, students, and others who are interested in science and technology policy. This year's forum had more than 400 participants, including John H. Marburger, the Director of the Office of Science and Technology Policy (and Science Advisor to the President), who gave his seventh consecutive keynote address, as well as concerned parties from government, universities, research-related institutions, and think-tanks.

The plenary sessions covered topics as follows; "Budgetary and Policy Context for R&D in FY 2009", "What Kind of World will Science and Technology Face - and Help Create - in the 21st

Year	Plenary sessions	Concurrent sessions
2004[2]	・Budgetary and Policy Context for R&D in FY 2005 ・Challenges for the U.S. in the Evolution of the Global Economy ・The Impact of Post-9/11 Security Policies on Science	・Policy Implications of Converging New Technologies: Nano-, Bio-, Cognitive ・Will Technology Enhance or Erode Democracy? ・How Sustainable is the Modern Research University?
2005	・Budgetary and Policy Context for R&D in FY 2006 ・The Role of R&D in the U.S. and Global Economies ・Science versus Society? When Scientific Interests and Public Attitudes Collide	・The Future of Scientific Communication ・A Systematic View of the S&T Workforce ・Science and Global Health Disasters
2006[3]	・Budgetary and Policy Context for R&D in FY 2007 ・The Global Innovation Challenge: Responses by Industry and U.S. Policy Makers ・Protecting the Integrity of Science	・Science and Technology Policy for the Energy Challenges of the 21st Century ・Risk and Response: Coping With Uncertainty About Pandemic Flu and Other Global Health Threats ・Homeland Security: Can Science Make Us Safer?
2007[4]	・Budgetary and Policy Context for R&D in FY 2008 ・Pharmaceutical and Biotechnology R&D ・Security Issues and Disclosure of Scientific Information	・States' Expanding Role in Science and Technology Policy ・Building Science, Technology, and Innovation Capacity in Developing Nations ・Surveillance, Privacy, and the Roles of Science and Technology
2008	・Budgetary and Policy Context for R&D in FY 2009 ・What Kind of World will Science and Technology Face - and Help Create - in the 21st Century? ・Science & Technology, the 2008 Election, and Beyond ・Science and the New Media	・Human Enhancement: Promise and/or Threat? ・New Models for Funding Research and Innovation ・Advocacy in Science: Models for the Future

Figure 1 : Session topics from 2004 to 2008

Source: AAAS Forum on Science and Technology Policy website.[1] Please refer to References[2-4] for previous forums.

Century?", "Science and Technology, the 2008 Election, and Beyond", and "Science and the New Media". In recent years, the session on R&D budget has always started with the keynote address and the analysis of R&D budgets for the subsequent fiscal year, and presentations on policy background followed. However, this year, only the keynote address and budget analysis were presented, and then, a separate session, "What Kind of World will Science and Technology Face - and Help Create - in the 21st Century?", which focused on the global outlook, took place. Other characteristics of this forum were as follows: the main focus was the presidential election and beyond; all the topics were issues in peacetime, that is, no issues on existing threats such as national security and infectious diseases were seen; and there was focus on science technology in general rather than specific areas. Figure 1 shows the session topics of the past five forums.

2 Keynote address

John H. Marburger, the Director of the Office of Science and Technology, first mentioned expected involvement of scientific community in the incoming presidential administration. He made a point that those who may be eligible for senior positions and be involved in science and technology policymaking under the new administration would have to prepare. He also said that the scientific community should take actions by considering appropriate candidates who would be willing to take such difficult positions, before the incoming administration begins to function.

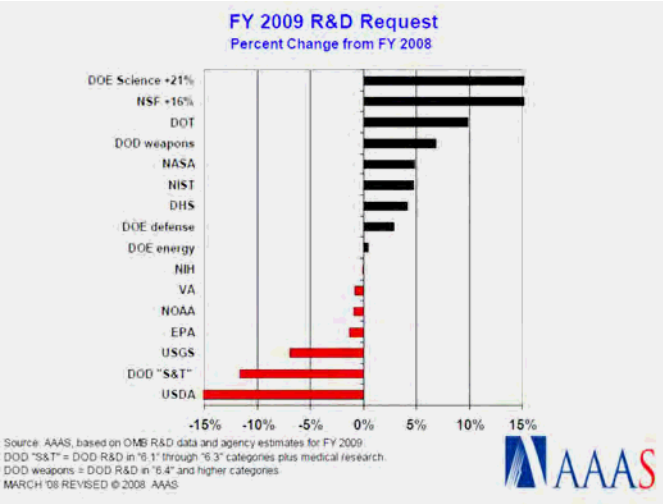
For the allocation of R&D budget, he reiterated that the U.S. lacks management framework and various stakeholders are involved in policymaking process, while many other countries have such frameworks for budget allocation. As an example, he referred to earmarks, which reflect intentions of congress and relevant parties. He questioned whether allocations were optimized, recognizing each earmark was worthwhile. He added that the overall picture shows that the percentage of R&D funding in the discretionary budget is remarkably stable although the mandatory budget is pressuring the discretionary budget.[NOTE2]

[NOTE1]
The AAAS is one of the largest international non-profit organizations with more than 140 thousand members that consist of scientists, engineers, science educators, policy makers, and others, and it is the publisher of the journal "Science". (Excerpt from reference[4])

[NOTE2]
Mandatory budget is expenditure that the government is obliged by law, such as pensions, health insurance, bond, and others. Discretionary budget that includes R&D funds is expenditure where the amount is decided according to the appropriation act that congress passes each year.

[NOTE3]
A program that was revealed in the president's budget request on February 2006 and at the same time by the Office of Science and Technology Policy (OSTP). To increase the competitiveness of the U.S., the program emphasizes the increase in support for basic research in physical science and engineering, and basic improvements in mathematics, science, and engineering education from elementary to higher educations. The core for supporting basic research is to double the funding over a ten-year period for agencies such as the NSF, DOE Science and NIST.

[NOTE4]
A legislature enacted in August 2007 for promoting investment into innovation and education for increasing the competitiveness of the U.S. This was in response to recommendations in the National Academies report "Rising Above the Gathering Storm". It promotes the increase in support for basic research, strengthening of science, engineering and mathematics education, and promoting high-risk and high-reward innovation research.



DOE: Department of Energy
NSF: National Science Foundation
DOT: Department of Transportation
DOD: Department of Defense
NASA: National Aeronautics and Space Agency
NIST: National Institute of Standards and Technology
DHS: Department of Homeland Security
NIH: National Institute of Health
VA: Department of Veterans Affairs
NOAA: National Oceanic and Atmospheric Administration
EPA: Environmental Protection Agency
USGS: U.S. Geological Survey
USDA: U.S. Department of Agriculture

Figure 2: Changes in U.S. FY 2009 R&D budget per agencies (compared to previous fiscal year)
Source:Presentation by Kei Koizumi (AAAS) [1]

As for prioritization, he criticized the 2008 R&D budget allocation by congress for not reflecting the priorities in the ACI[NOTE3] (American Competitiveness Initiative), or the America COMPETES Act[NOTE4] (America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act) as indicated in the president's message. He pointed out that appropriate allocation would be important because it would be difficult for the incoming administration to match the increase during the Bush administration which increased R&D budget compared to the eight years before that. He further mentioned that there is a large and unhealthy imbalance among funds for biomedical research and others although federal support for biomedical research has been left unchanged for half a decade.

3 Presentation on federal R&D budgets for FY 2009

Kei Koizumi of AAAS presented his analysis of the FY 2009 R&D budget as follows: In February 2008, the President proposed a $3.1 trillion budget for FY 2009 in his budget message. It remains flat from the previous year. R&D budget (research, development, and facility) is $147.4 billion, which also remains flat in recent years. Among these, research budget peaked in FY 2004 and shows decreasing trends.

The FY 2009 budget proposal mentions a significant boost for basic research in physical sciences in accordance to the ACI and America COMPETES Act. Budgets for the National Science Foundation (NSF), Department of Energy (DOE) Office of Science, and National Institute of Standards and Technology (NIST) are to be significantly increased (Figure 2). They could make up for the shortage and double the funds over a ten-year period as stipulated in the ACI. There are also increases for the Department of Defense (DOD) and National Aeronautics and Space Agency (NASA). Budget for the National Institute of Health (NIH) is flat, and those for

[NOTE5]
Earmarks, in U.S. politics, refer to congressional provisions that specify certain spending priorities to specific projects. Earmarks do not exist at the point of the FY 2009 President's budget request to congress. Therefore, R&D funds may appear to be reduced when this is compared to the FY 2008 appropriation with earmarks, which was approved by congress. However, this does not mean that the funds were actually reduced. For this reason, the science advisor to the President, John H. Marburger mentioned that the AAAS budget analysis is flawed at the 2007 forum.[4] Then, for the FY 2009 budget analysis, the AAAS calculated the funding increase and decrease per agency excluding earmarks, and showed that DOD Science & Technology had 5.6% increase, while USDA had 1% decrease.

the Environmental Protection Agency (EPA), Department of Defense Science and Technology (DOD S&T), and U.S. Department of Agriculture (USDA) decrease. However, the latter two eliminates earmarks, and therefore, shows decrease compared to the FY 2008 budget (appropriation) which includes earmarks.[NOTE5]

He also analyzes the trends in world R&D investments. The U.S. still leads R&D performance, but Asian countries such as China and India are dramatically increasing their R&D investments and beginning to show their presence. Also shown are the sharply increasing trends with Japan, South Korea, and China in R&D investments as percentage of GDP.

The president's budget request proposes budget allocation in accordance to the ACI, but he provided the prospect that there were possibilities that congress would cut ACI-related increases in order to allocate resources to other programs unless the gross budget ceiling would be raised.

4 Other presentations

4-1 Science and technology in the 21st century

In the session, "What Kind of World will Science and Technology Face - and Help Create - in the 21st Century?", presentations with long-term perspectives were given on global-scale issues and on new societies that science could create. They indicated the need to tackle global scale issues in climate change and energy by rallying the knowledge of science and technologies from around the world.

James Canton of the Institute for Global Futures provided predictions of the world with an interdisciplinary approach by analyzing multi-tiered trends to understand complex future societies. He envisioned the future as follows: The risk factors would be energy, population, food, water, health, poverty, climate change, terrorism and so on. Among these, energy and water could be priority issues that would need to be tackled. Innovation would be the key in solving these issues, and science would be the driving force of innovation. Furthermore, he presented an outlook of science where nano-, bio-, info-, quantum, and cognitive sciences would converge.

Melinda Kimble of the United Nations Foundation cited future threats to planetary sustainability, such as water stress, random urbanization, socioeconomic disparities and climate change. With such bleak outlook of the future, she emphasized the necessity of appropriate and effective policies on the basis of scientific evidence, and global cooperation and coordination to salvage the endangered planetary sustainability.

Christopher T. Hill of George Mason University predicted a transition from the current "scientific society" to a "post-scientific society". This "post-scientific society" was described as a society where issues such as climate change, energy supply and demand, creating wealth and economic growth would be solved through the global science and technology community working together. He reminded the audience that science would still play an important role in a post-scientific society. The background for this transition is globalization, increased science and technological capabilities around the world and internationally diversified scientific and technological human resources.

4-2 Recommendations for the presidential election and beyond

At the session for "Science and Technology, the 2008 Election, and Beyond", presentations were given on the 2008 presidential election and beyond, and on issues for the incoming administration, as well as on actions that scientists should take. Some of the important issues that were discussed in this session are summed up as; health care, climate change, and energy. Furthermore, the scientific community was encouraged to be more actively involved in the science and technology policymaking in the incoming administration.

Peter R. Orszag, the Congressional Budget Office Director, mentioned health care and climate change as the major issues for the incoming administration. He indicated the possibility of continuously growing health care costs because of rising medical cost per patient as technology improves, and the increasing numbers of Medicare and Medicaid beneficiaries. With climate change, he made a point that we should try to reduce small risks that could cause catastrophic conditions in the future.

Robert C. Cresanti of Ocean Tomo, LLC. emphasized that the next administration should seek policies to transform tax-supported research

results into tangible and intangible assets, and to make use of intellectual properties to serve economic growth. As for administration, he pointed out that the current issue was the decline in investment for coordination among science-and-technology-related government agencies. He also mentioned the lack of engagement of the scientific community with the inner circle of the administration.

Gilbert S. Omenn of the University of Michigan said that the new administration should reorder priorities in the current policies affected by previous changes such as 9/11 and Iraqi War. He set priorities for the new administration as follows: 1) Address long-deferred issues, such as energy, global environment, the economy, the workforce, education, health, and infrastructure. 2) Create renewed strategic plans for defense, space, homeland security, and intelligence. 3) Repair/revive international relationships. 4) Make clear the critical contributions from science and technology to the nation's future and strengthen the base for research and innovation and policy advice.

John Edward Porter, former U.S. Representative, urged scientific community to try to have science and technology issues heard by candidates in the presidential and congressional elections. Some of the issues he suggested are as follows: Identify and prepare the list of potential nominees for top science and technology related positions. Sign on to "sciencedebate2008"[NOTE6] to have presidential candidates debate on science issues. Invite Representatives and Senators to campus to see what's happening in research.

Ernest J. Moniz of MIT brought up how the change of administration could affect the continuity of a research project, giving examples in energy related research. He said as follows: Basic research programs that have broad support from scientific community have a high possibility of surviving the transition of administrations. However, development or demonstrative researches endorsed by administration are vulnerable to administration change, and such investments would fail to come to fruition. He added out that demonstration projects under conventional government agency structures had uncertainties about resources arising from the annual appropriations. And he also pointed out the necessity of comprehensive discussion considering policies other than energy.

4-3 Science and the new media

Presentations were given on the possibilities and the current state of the new media as means of science communication, and focused on blogs and virtual worlds, which came from improvements and spread of the internet. It was indicated that these could become highly usable in the future.

Adam Bly of Seed Media Group indicated the importance of designs, based on his experience in publishing general scientific journals and planning scientific exhibitions in art museums. He added that the interaction between scientists and artists would give birth to a new form of expressions. As for blogs, he said that his website for science blogs had increased access from abroad, where global discussions were beginning to take place. He recognized that this was a new movement in communication between scientists and the public. He further provided view that the blog would be a useful means for peer review of research, enhancing public understanding of science and technology, science education, and others.

As a blogger herself, Sheril R. Kishenbaum of Duke University highly valued the blogs as a means to transmit information and fill the gap between policy and expert knowledge of science.

[NOTE6]
Non-committed activity that calls for debate on science and technology by potential presidential candidates. The site calls for participation, and will be held even if there is only one candidate participating, by setting the date, time and place of debate. Supporters are being continuously sought though the website, with individuals such as leading scientists including Nobel prize laureates, government leaders, university and academic leaders, and organizations such as the AAAS, The Council on Competitiveness, and The National Academy of Sciences. Sheril Kirshenbaum, who presented at the session "Science and the New Media", is a member of the acting committee of this activity.

She characterized blogs as a tool for speedy and interactive communication with a very wide range of readers. With these characteristics, one example that demonstrated the power of the blog is how "Science Debate 2008" was organized in a few months.

Anthony Crider of Elon University introduced the experience of creating SciLands, a virtual island that provides the opportunities to get familiar with science and technology, within the virtual world of Second Life. The SciLands has the planetarium that he developed there, and other facilities that have been set up, such as by universities, museums, and NASA. Citing that many children have participated in the virtual world, and that NASA is calling for organizations to participate in the development of tools and operation, he said that the virtual world would play a major role in future science education.

4-4 New models of funding

Presentations were given on the different types of funding adequate to research and development stages, and on a variety of funding organizations in the U.S. For the research and development stages, transformative research[NOTE7], with its importance being emphasized, and venture business were mentioned. For funding organizations, foundations, prizes and awards, and state governments were mentioned. It was indicated that the diverse funding system was supplementing funds from the federal government.

John C. Crowley of the American Academy of Arts and Sciences said that under the current funding constraints, researches that appear to yield results are easy to be funded. Therefore, to promote transformative research that is difficult to yield results, it is necessary to revise the review process. Specifically, he emphasized the evaluation of new ideas and creativity, considering the length of time needed to yield results.

Stephen A. Merrill of The National Academies introduced the various prizes according to their characteristics. Then, he mentioned that apart from helping to achieve research objectives, the prizes promote participation into the research field, attract investors, and educate the public. However, he indicated issues in organizing the prize that involves large sums of money and effort. He further mentioned the need to deepen understandings of factors that promote or obstruct the effect of prizes.

Suzan M. Fitzpatrick of the James S. McDonnell Foundation, [She was absent from the meeting, and her presentation was introduced by moderator Donna J. Dean of Lewis Burke Associates LLC.] showed how many philanthropic foundations, with diverse policies, are funding research in the U.S. It was mentioned that the general characteristics of funding by foundations are in taking risks, and supporting ideas prior to broader acceptance, such as topics where government is reluctant to support or topics in their early stages of research.

Dan Berglund of the State Science and Technology Institute indicated that the characteristics of funding by state governments are basically mission oriented. The objectives are to improve research capabilities with a focus on economic development. He cited an example of the Research Triangle Park in North Carolina, which showed significant progress in 40 years, and said that it is yet to yield results, but taking or not taking actions would have greatly changed the future of the state.

Ravi Kapur of Anudeza Consulting Group stated that venture capital had become risk-averse, and therefore, to fund entrepreneurs, the effectiveness of funding by government should be improved. He said, "If we continue to focus on increased money for idea generation, and not enough on innovation for conversion to commerce, we will run the risk of subsidizing innovation for the rest of the world". He also stated that the federal government should carefully consider the disparity in allocating funds into basic research and into innovation.

[NOTE7]
Research concept revealed in the "2020 Vision for the National Science Foundation" by the NSF in 2005. It aims to "revolutionize existing fields, create new subfields, cause paradigm shifts, support discovery, and lead to radically new technologies". Specifically, research by Albert Einstein, Barbara McClintock, and Charles Townes are mentioned.

5 Conclusion

Presentations showed a strong intention to make a fresh start and discuss future science and technology policy as the Bush administration is about to come to an end after such significant incidents as 9/11 and the Iraqi War. In the background is the sense of urgency that the superiority of the U.S., which held the lead in science and technology, could be undermined in seeing the rapid growth of China and India. The presentations had frequent mentioning of China and India, while there was no mentioning of Europe or Japan.

Many presentations picked up the climate change issue, where a AAAS Board Statement was released at the 2007 forum[4] and the energy issue, which was the session topic at the 2006 forum,[3] as the priority issue in science and technology that the new administration should tackle. The science and technology policy appears to need a long-term view in solving problems for establishing a sustainable society.

Before the coming presidential election, the AAAS is actively involved in various activities to have the views of the scientific community reflected in policies. For example, their website has the page "S&T in the 2008 Election" that provides information on policies and views of candidates from both parties. The AAAS annual meeting that was held in February 2008 had session for discussion on science and technology policy, inviting science and technology advisers to Senators Hillary Clinton and Barack Obama. Then, the forum promotes individual scientist and the science community to not only speak out to presidential candidates and politicians, but to take actions and to be actively involved in the process of making science and technology policies. With distinctive political process in each country, it is interesting to see the big difference in the scientific communities of the two countries.

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About SCIENCE AND TECHNOLOGY FORESIGHT CENTER

It is essential to enhance survey functions that underpin policy formulation in order for the science and technology administrative organiztions, with MEXT and other ministries under the general supervision of the Council for Science and Technology Policy, Cabinet office (CSTP), to develop strategic science and technology policy.

NISTEP has established the Science and Technology Foresight Center (STFC) with the aim to strengthen survey functions about trends of important science and technology field. The mission is to provied timely and detailed information about the latest science and technology trends both in Japan and overseas, comprehensive analysis of these trends, and reliable predictions of future science and technology directions to policy makers.

Beneath the Director are six units, each of which conducts surveys of trends in their respective science and technology fields. STFC conducts surveys and analyses from a broad range of perspectives, including the future outlook for society.

The research results will form a basic reference database for MEXT, CSTP, and other ministries. STFC makes them widely available to private companies, organizations outside the administrative departments, mass media, etc. on NISTEP website.

The following are major activities:

1. Collection and analysis of information on science and technology trends through expert network

— STFC builds an information network linking about 2000 experts of various science and technology fields in the industrial, academic and government sectors. They are in the front line or have advanced knowledge in their fields.

— Through the networks, STFC collects information in various science and technology fields via the Internet, analyzes trends both in Japan and overseas, identifies important R&D activities, and prospects the future directions. STFC also collects information on its own terms from vast resources.

— Collected information is regularly reported to MEXT and CSTP. Furthermore, STFC compiles the chief points of this information as topics for “Science and Technology Trends” (monthly report).

2. Reserch into trends in major science and technology fields

— Targeting the vital subjects for science and technology progress, STFC analyzes its trends deeply, and helps administrative departments formulate science and technology policies.

— The research results are published as articles for "Science Technology Trends" (monthly report).

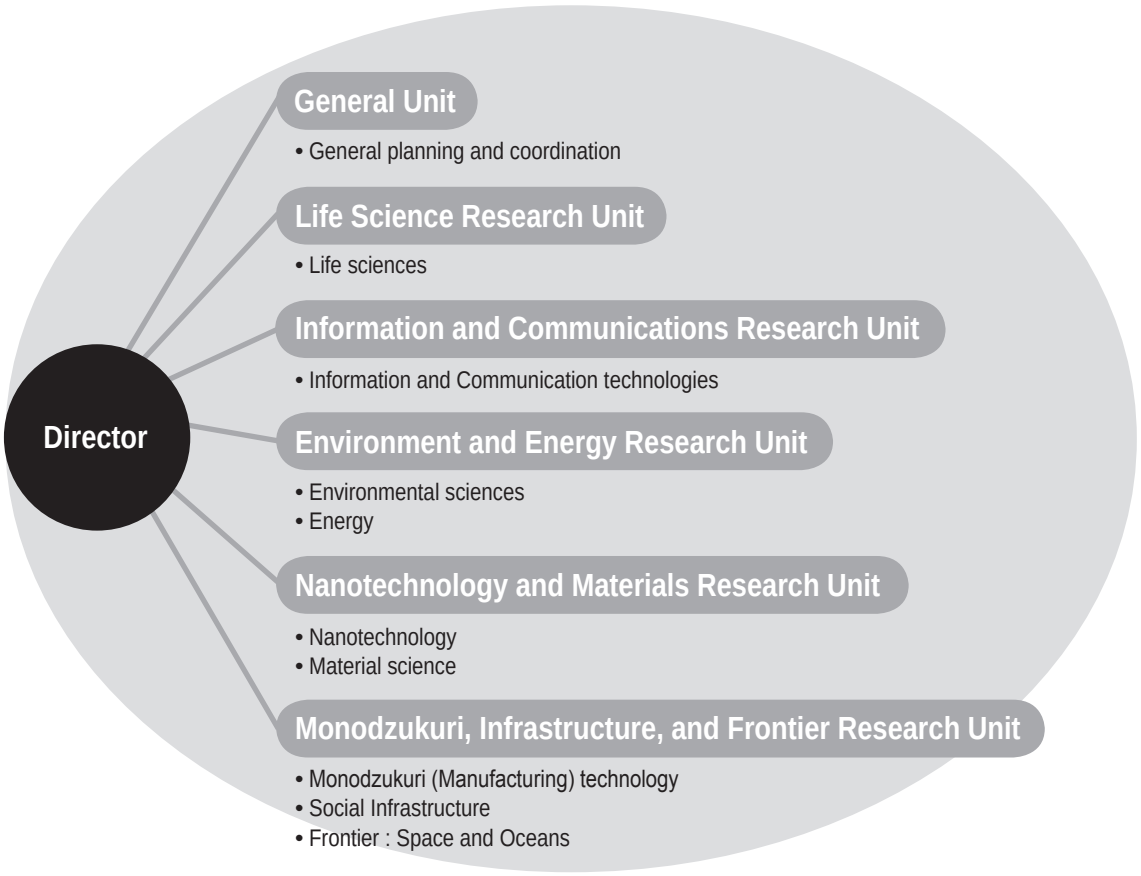
3. S&T foresight and benchmarking

— S&T foresight is conducted every five years to grasp the direction of technological development in coming 30 years with the cooperation of experts in various fields.

— International Benchmarking of Japan's science and engineering research also implemented periodically.

— The research results are published as NISTEP report.

Organization of the Science and Technology Foresight Center



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＊The Center's organization and responsible are reviewed as required

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