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Life Sciences

Potential of Controlled Environment Agriculture in a Super-Aging Society

Information and Communication Technologies

Standardization of Electronic Commerce in the Cloud Environment and Its Future Evolution

Issues Surrounding Standardization and Promotion of Web Accessibility

Robust and Usable Media for Communication in a Disaster

Nanotechnology and materials

Recent Trends in Neutron Beam Assisted Material Analysis Technology

Others

Initial Responses to the Great East Japan Earthquake by the Academic Community in the United States

NISTEP

Science & Technology Foresight Center
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Science & Technology Foresight Center of NISTEP

Executive Summary

Life Sciences

1 | Potential of Controlled Environment Agriculture in a Super-Aging Society

p.**9**

Japanese society has been aging at an unprecedentedly rapid pace, and population aging is expected to accelerate in metropolitan areas in particular in the future. Due to extended life expectancy, people have come to have a longer post-retirement life. In a society where the productive-age population ratio declines in line with an increasing aging population, it is necessary to develop a new living environment in accordance with changes in social structure. Particularly in urban areas, new employment opportunities need to be prepared for elderly people who are willing to work so that they can continue to work, depending on their physical strength, even after retirement.

Based on multiple survey results, agriculture and gardening is a popular pastime for the elderly. It is widely known that agricultural work and gardening have good effects on people's mental and physical health, and they are expected to help improve the quality of life of the elderly. Therefore, the agriculture-related sector may have the potential to provide proper employment opportunities for the elderly. In recent years, with growing environmental awareness and inclination toward an enriched lifestyle, more and more people in cities have come to enjoy the casual cultivation of plants and vegetables in rooftop gardens in cities. Such mode of agriculture has already been commercialized in foreign countries. Furthermore, a new style of agriculture is being tried at rooftop hydroponic facilities by controlling parts of the cultivation environment, such as humidity, water, and nutrients.

Controlled environment agriculture ensures comfortable working conditions throughout the year, while requiring a relatively light work load. If there are places available in cities where people can engage in controlled environment agriculture, in addition to ordinary farmland in rural and suburban areas, the elderly may be able to take part in agriculture in various manners, according to their respective health conditions, physical strength, and lifestyle.

An example of the technological development necessary to realize controlled environment agriculture can be seen in studies on the commercialization of plant factories. When considering the creation of jobs to be the major purpose, a reduction of construction costs and operation costs (such as electricity costs) of facilities, the development of environmental control technology suitable for the Japanese climate, the preparation of an environment where workers can have incentives to grow plants, and the adoption of universal design principles are indispensable. It is also technically possible to grow plants in buildings, not only at rooftop facilities, with the use of artificial light. This type of agriculture may provide jobs for people across all age groups, in addition to elderly people. If the target can be expanded to cover all city residents, the social value of controlled environment agriculture will be further enhanced. As many other foreign countries are also expected to face the problem of an aging population in the future, a new city model in Japan that introduces controlled environment agriculture may serve as a useful reference for them.

(Original Japanese version: published in May 2011)
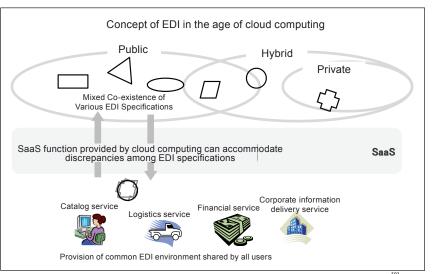
Information and Communication Technologies

2 | **Standardization of Electronic Commerce in the Cloud Environment and Its Future Evolution**
p.**21**

Electronic Data Interchange (EDI) is a standardized rule-based means of electronic data exchange using a set of structured alpha-numeric linguistic strings, and constitutes an essential part of electronic commerce among enterprises for transferring a variety of documents (management, commercial, transport, etc.). With the rapid expansion of the Internet in the 1990s and thereafter, a type of EDI that takes advantage of the generally available Web services, or Web-EDI, has come into widespread use. However, insufficient standardization within the industries has led to the existence of multiple and dissimilar Web-EDI systems even in a single business sector, posing a problem that hinders the smooth flow of commercial transactions, i.e. the multi-screen phenomenon. Many enterprises that have introduced Web-EDI are faced with difficulties when trying to integrate it with their existing in-house system because there are various customer-specific EDIs. In Japan at present, 80 to 90 percent of major distributing and manufacturing enterprises have already introduced EDI, but only 10% or less of small enterprises are actually using EDI for their transactions.

Cloud computing has become the focus of attention in recent years because of its potential to invoke drastic changes both for the providers of enterprise information systems (IT vendors) and the users (enterprises at large). From the viewpoint of constructing and operating an EDI system, the utilization of the cloud environment helps reduce initial investment for IT system introduction and allows simpler co-existence of different EDI systems working in harmony. These characteristics raise the possibility of alleviating the multi-screen phenomenon, boosting the diffusion of EDI in many enterprises, especially in smaller ones.

As cloud computing, motivated by reduced initial investment, makes its way into a broader spectrum of enterprise activities, cloud-based EDI is expected to gain a wider share, especially among small and medium-sized enterprises. An open standard is required to provide effective use of EDI in the evolving cloud environment. In many countries other than Japan, EDI services are provided by public organizations. It is desirable that a free market mechanism will be established to distribute software functions supporting EDI services. A number of small and medium-sized software vendors could provide a spectrum of software for the multitude of new services required. Standardization efforts from a neutral point of view are the essential part of promoting EDI introduction: an activation of collaborative efforts among universities and industrial sectors is highly desirable toward this goal, as exemplified by many cases in foreign countries.

(Original Japanese version: published in April 2011)

Figure : EDI in the age of cloud computing: as envisaged by JEDIC[6] Concept of EDI in the age of cloud computing

Information and Communication Technologies

3 | **Issues Surrounding Standardization and Promotion of Web Accessibility**　　　p.**32**

If anyone can access a piece of information, we say that the information is "accessible." In the case of website information, this quality is referred to as "web accessibility." When the Great East Japan Earthquake occurred on March 11, 2011, some websites providing public information were not accessible, and there were many cases where web accessibility was not given sufficient consideration.
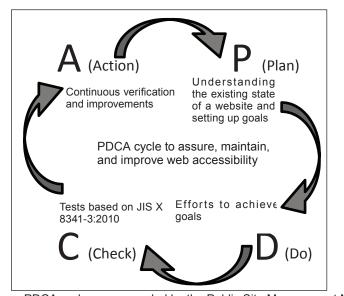
In order for various individuals to be able to use the web not only during a crisis but also for everyday life, the Japanese Industrial Standard (JIS) X 8341-3, "Guidelines for older persons and persons with disabilities - Information and communications equipment, software and services - Part 3: Web Content" was published to establish unified technical specifications. The JIS has three characteristics: 1) a grading system was adopted to establish three conformance levels, and so, for example, level A conformance must conform to 25 success criteria; 2) the success criteria are, in principle, testable, and 3) the success criteria are described without referring to specific technology.

In recent years, countries around the world have been active in promoting web accessibility. In Japan, the Web Accessibility Infrastructure Committee (WAIC) has published "Accessibility Supported User Agent Information," "Test Guidelines," and other related documents. A "Public Site Management Model" was also provided to the central, prefectural, and municipal governments to encourage them to improve web accessibility in a systematic and continuous manner. In addition, the Japan Web Accessibility Consortium was established in April 2010 and it began working to improve the accessibility of both public and private websites.

In the United Kingdom, "Web Accessibility - Code of Practice" was published to bring together matters that needed to be managed systematically, and the Accessibility Maturity Model was also proposed. Organizations can use the model to self-assess the accessibility performance of their information and communications systems, products, and services.

Website providers need to further heighten their awareness of accessibility on a regular basis.

(Original Japanese version: published in May 2011)

A (Action)
Continuous verification and improvements

P (Plan)
Understanding the existing state of a website and setting up goals

PDCA cycle to assure, maintain, and improve web accessibility

Tests based on JIS X 8341-3:2010

Efforts to achieve goals

C (Check)

D (Do)

Figure : PDCA cycle recommended by the Public Site Management Model
Taken from the Public Site Management Model

4 ## Robust and Usable Media for Communication in a Disaster

p.**44**

After the occurrence of the Great East Japan Earthquake on March 11, the Internet connectivity remained more robust than expected, whereas telephone services and texting on mobile phones were disrupted. This is because the Internet itself possesses robustness: Internet traffic bypasses damaged places automatically so that the Internet can be always accessed at any time. The optical undersea cables, whose north route was damaged, stayed connected to the world through the south route serving as a bypass. Social networks, such as Twitter, which are flexible and open systems, were recognized as an effective tool for public communication in the event of disaster. The government and public organizations also started to utilize social networks. In addition to the Internet connectivity, the scalability, that can address a rapid increase in the flow of information and data processing, is important to the robustness against disaster. Twitter ensures scalability by using the external cloud service and Skype by the technique referred to as super-node. There are also means such as mirror sites to ensure scalability of websites.

The TV and other mass media broadcasted prompt reports including the earthquake and tsunami warnings, and they kept showing the devastating videos of the disaster. However, they failed to transmit sufficient information necessary for disaster victims because there were a huge number of victims spread across a wide area. This weakness was compensated by the Internet and social networks supported by many volunteers. Volunteers marked the locations of evacuation shelters for stranded commuters on the map, which resulted in a real-time map (Figure) of shelters in the metropolitan area. Volunteers also helped to launch the "Person Finder" where people can search for information about safety confirmation of victims. The Internet and social networks were used as the most powerful media in the event of disaster because they have not only the robustness but also the following characteristics; the openness that allows people to touch up them quickly in order to gather and transmit the necessary information to or from victims, and the familiarity in the sense that people use them every day.

In the event of disaster, it is crucially important to gather information quickly and to transmit information after the integration in a user-friendly manner. To that end, we need to build an open information infrastructure that can attract volunteers scattered all over the nation.

(Original Japanese version: published in June 2011)

Figure : Real-time map of evacuation shelters

Source: Cited from Reference 11

Nanotechnology and materials

5 | Recent Trends in Neutron Beam Assisted Material Analysis Technology

p.**56**

Neutron beams have a peculiar characteristic among the classes of quantum beams: they interact only with the atomic nucleus and, because they have no electrical charge, are not affected by the electrons inside substances. Application of the neutron beam in material analysis enables detection and analysis of light elements, such as hydrogen and lithium, which are mostly beyond the reach of traditional X-ray and electron beam methods. The electrical neutrality of the neutron made it difficult to create and control a neutron beam by means of electrical force, i.e. an electrical field, and has resulted in a high level of technical difficulties in the development of high-intensity sources, resulting in a delay in practical applications in comparison with other quantum beams such as X-rays and electron beams. In recent years, however, many large-scale facilities capable of producing high-intensity, high-quality neutron beams have came into operation in various countries, including the Japan Phroton Accelerator Research Complex (J-PARC) that allows access to neutron beams with the world's highest level of intensity. This trend has helped in stepping up material research using neutron beams in various countries.

The achievements in recent years include detailed structural analysis of lithium-ion battery electrodes and proteins with rich hydrate contents using a high-intensity, high-quality neutron beam. The usefulness of these techniques is somewhat limited, however, by the prolonged measurement time and the need for a large crystal sample. Substantial effort is being made to increase the beam intensity to a level that will enable shorter measurement time and smaller samples. Future availability of more accurate analysis of lithium and hydrogen, and structural analysis of a wider variety of biological materials will provide an essential infrastructure for the development of new energy devices and pharmaceutical agents. Through the use of the neutron's excellent capacity to penetrate through materials, future development of small sources can increase the possibility of neutron beam applications in such areas as structural defect detection (e.g. structural objects made of metal and ceramic) and security purposes (e.g. baggage inspection).

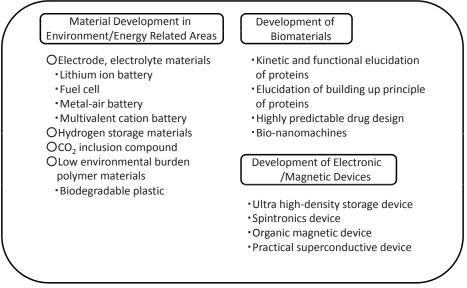(Original Japanese version: published in April 2011)

Material Development in Environment/Energy Related Areas

○ Electrode, electrolyte materials
  ・Lithium ion battery
  ・Fuel cell
  ・Metal-air battery
  ・Multivalent cation battery
○ Hydrogen storage materials
○ CO_2 inclusion compound
○ Low environmental burden polymer materials
  ・Biodegradable plastic

Development of Biomaterials

・Kinetic and functional elucidation of proteins
・Elucidation of building up principle of proteins
・Highly predictable drug design
・Bio-nanomachines

Development of Electronic /Magnetic Devices

・Ultra high-density storage device
・Spintronics device
・Organic magnetic device
・Practical superconductive device

Figure : Areas of Material Analysis Where the Neutron Beam Can Play an Important Role

Prepared by the STFC

Others

6 | **Initial Responses to the Great East Japan Earthquake by the Academic Community in the United States**   p.**66**

The Great East Japan Earthquake and the subsequent nuclear power plant accidents had great impact not only on Japan but also on countries around the world. The academic community in the United States has taken a variety of actions, including making both long-term proposals for policymaking and urgent proposals to provide information to researchers and the public as well as advice and assistance on national policymaking related to disasters and accidents. Many academic organizations have provided information through their websites. In particular, large academic organizations and organizations specializing in earthquakes and nuclear plant accidents have provided on-site reports and other information and have conducted scientific analyses.

Some websites have provided information not only to researchers but also to the general public. For example, the American Association for the Advancement of Science (AAAS) has published news articles about the earthquake and nuclear plant accidents in Science, and medical organizations such as the American Society for Radiation Oncology (ASTRO) and the American Academy of Pediatrics have provided radiation-related information to educate the American public. In the United States, academic organizations usually provide information to the public as well as offer advice and make proposals to related organizations and the government. The American Nuclear Society (ANS) announced that it would support the Atomic Energy Society of Japan (AESJ) and the United States government. Out of concern for conflicting information and misleading media reports, ANS also asked the government to withhold policy decisions concerning nuclear power. In some cases, the academic community has also proposed solutions to scientific and technological problems facing the Japanese government, Tokyo Electric Power Company (TEPCO), and the United States government. In addition, during congressional hearings on the accidents at the Fukushima Daiichi nuclear power plant, testimony was heard not only from the Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE) but also from the academic community, which holds a different point of view from government organizations.

It should also be noted that the academic community in the United States exists in a different environment than the Japanese academic community. For example, American academic organizations have strong management bases, the earthquake and the nuclear power plant accidents have been taken very seriously even though they occurred in another country, and many different kinds of information were distributed quickly through the Internet following the disasters.

The American example suggests that academic communities can play four roles in regard to disasters and accidents: sharing of information, providing assistance to people, contributing to policy making, and swiftly conducting academic research.

(Original Japanese version: published in June 2011)

1

Potential of Controlled Environment Agriculture in a Super-Aging Society

Kazuhito Akasaka
Life Science Research Unit

1 | Introduction

Japanese society has been aging at an unprecedentedly rapid pace, and the percentage of those aged 65 or over is expected to reach around 40% of the total population in 2050. Due to extended life expectancy, people have come to have a longer post-retirement life. In a society where the productive-age population ratio declines in line with an increasing aging population, new employment opportunities need to be prepared for the elderly who are willing to work so that they can continue to work, depending on their physical strength, even after retirement.[1] As the aging population is supposed to increase significantly in metropolitan areas in particular, environmental arrangements for a super-aging society are required both in urban areas and local areas.

Results of surveys on elderly people's life trends show that agriculture and gardening is one of the popular pastimes for the elderly. Furthermore, it is widely known that agricultural work and gardening have good effects on people's mental and physical health, and they are expected to help improve the quality of life. If new employment opportunities for the elderly can be prepared based on such features of agriculture and gardening, this will be a new city model for a super-aging society.

In recent years, with growing environmental awareness and inclination toward an enriched lifestyle, more and more people in cities have come to enjoy the casual cultivation of plants and vegetables in rooftop gardens. In the United States, a new style of agriculture is being introduced at rooftop hydroponic facilities, where plants and vegetables can be grown stably throughout the year. Bearing such new trends in mind, this report discusses the potential of controlled environment agriculture in urban areas in a super-aging society and explains recent studies on plant factories, which may hold the key to realize this new style of agriculture.

2 | Social Background of the Employment of the Elderly

2-1 Population aging will accelerate, especially in urban areas

Japan's total population peaked at 127.84 million in 2004 and has been in a long-term declining trend. It is estimated that the total population will decrease by nearly 26% to 95.15 million by 2050. During this period, the elderly population aged over 65 will increase by nearly 12 million, while the productive-age population aged between 15 and 64 will decrease by nearly 35 million. As a result, the population aging rate is estimated to increase from nearly 20% to 40%. The population will be sparse in most parts of the nation, while concentrated in some areas, such as the Tokyo and Nagoya metropolitan areas.[2,3] The increase rate of the elderly population will be high in the Tokyo, Nagoya, and other metropolitan areas during the period from 2005 to 2035 (Figure 1). Looking at the changes in the elderly population by prefecture, some prefectures start to show decreases in and after 2020. As of the year 2035, prefectures that hold a large number of elderly people will be those with big cities, such as Tokyo, Kanagawa, Osaka, Saitama, and Aichi.[2,4] Based on these data, it is clear that population aging will progress nationwide and demographic composition will change drastically, particularly in big cities. Therefore, it is necessary to develop an environment that can respond to the coming super-aging society in urban areas, including big cities.
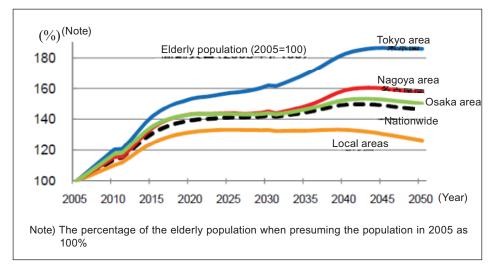
Note) The percentage of the elderly population when presuming the population in 2005 as 100%

Figure 1 : Changes in Elderly Population by Urban Area
Source: Reference[2] with data partially added by the STFC
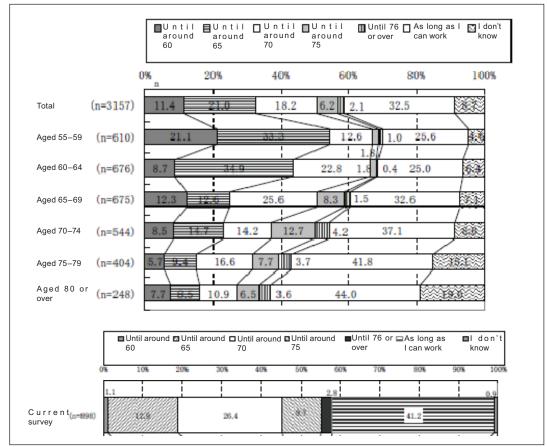

Figure 2 : Until What Age do You Want to Work?
Source: Extracted from Reference[5]

2-2 The quality of post-retirement life needs to be enhanced

The average life expectancy in 2008 was 79.29 for men and 86.05 for women, and may increase to 83.67 for men and 90.34 for women by 2055.[3] Life after retirement may lengthen to 20 to 30 years and the elderly need to consider how to spend this period of time and design their lives depending on their personal lifestyle.

Health conditions change with age, but many people want to work for the purpose of seeking satisfaction in life. The survey conducted by the Cabinet Office in 2007 shows that nearly 80% of the elderly aged 60 or over want to work until they become 70 years old[5] (Figure 2). In an aging society where the productive-age population decreases, new employment opportunities need to be prepared for the elderly who are willing to work so that they can continue to work, depending on their physical strength, and can maintain contact with local communities.

In the next Chapter, I will consider ideal workplaces for the elderly that respond to future changes in society, based on their lifestyle. I mainly cited data for the Tokyo metropolitan area, but the trend can be applied to other urban areas as well.

3 | Meaning of Gardening in Elderly People's Lifestyles

3-1 Many elderly people enjoy gardening

Based on the results of the survey conducted by the Ministry of Internal Affairs and Communications in 2006 concerning people's lives from the view point of leisure activities, among people aged 65 or over, the most popular hobby and entertainment was "growing plants and flowers, and gardening" (37.2% for men and 38.7% for women).[6]

According to the Internet survey conducted by the Tokyo metropolitan government in 2009, 84.6% of Tokyo citizens responded that agriculture and farmland need to be preserved in Tokyo and showed high interest in local agriculture. The major reasons for such response include the significance of agriculture in providing fresh and safe farm products
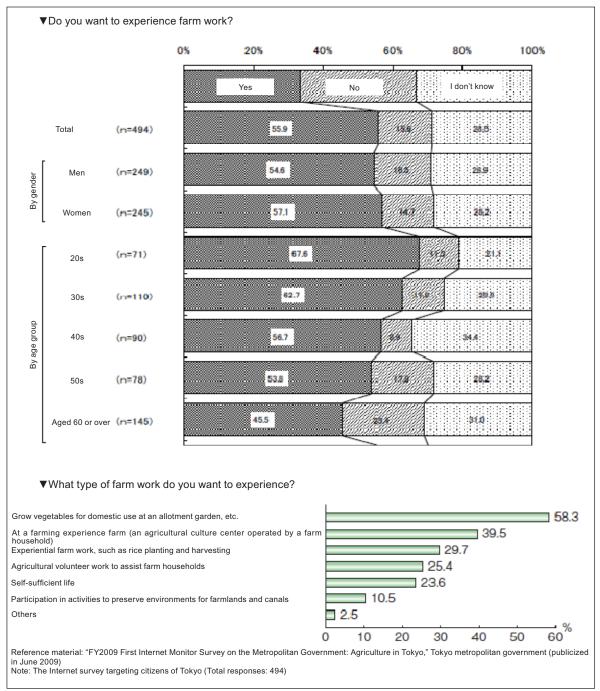

Figure 3 : Awareness Survey "Agriculture in Tokyo"

Source: Reference[7]

and animal products, and in preserving nature and the environment, as well as its educational function for providing dietary education. Those who want to experience farm work accounted for 56% of the overall respondents, showing high percentages widely among various age groups from 68% for those in their twenties to 46% for those aged 60 or over. Out of such respondents, those who want to grow vegetables at an allotment garden, etc. accounted for the highest percentage, at 58%[7] (Figure 3).
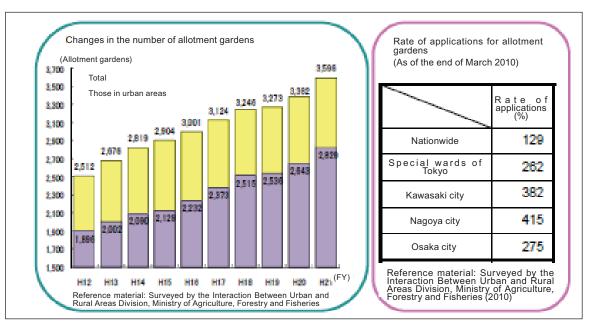
The number of allotment gardens has been increasing year by year nationwide. They are generally very popular as some have applicants on waiting lists, and the rate of applications is especially high in metropolitan areas[8] (Figure 4). According to the results of the survey conducted by the Kanto Regional Agricultural Administration Office of the Ministry of Agriculture, Forestry and Fisheries, targeting allotment gardens within its jurisdiction, 70% or more of the users are aged 60 or over[9] (Figure 5).
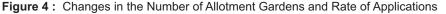
From these data, it can be said that gardening is one of the popular activity fields among the elderly and that a higher rate of the elderly in the Tokyo metropolitan area are actually enjoying cultivating vegetables, fruits and flowers in allotment gardens, etc. compared with those in other age groups.

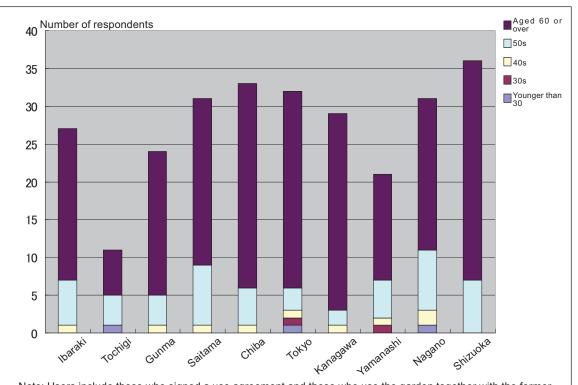## 3-2 Gardening are good for mental and physical health

In the fields of horticultural therapy and horticultural well-being, it is widely known that gardening activities help people enhance and maintain their physical functions through moderate exercise, and also has a good influence on their mind by having them feel nature with their five senses (touching soil, growing plants, enjoying greenery, tasting the harvest, etc.). Furthermore, through growing plants, people can have smoother conversation and can share harvests, which helps them build better human relationships and formulate communities.

Scientific analyses have also been conducted concerning these effects of gardening on people's health. For example, a medical epidemiological study has proved that gardening activities have positive influences on the health of elderly men in particular. A follow-up survey was conducted, targeting a total of 9,720 elderly people aged 65 or over who resided in five communities in Aichi prefecture and had not been certified as being in need of long-term care, regarding whether or not they develop dementia in the following three years, in relation to the types of their leisure activities. The results indicate that the risk of developing dementia nearly doubles for elderly men who do not enjoy gardening or growing plants, compared with their counterparts who enjoy such activities[10] (Figure 6). Gardening, which are highly accessible for the elderly, are expected to help enhance the quality of elderly people's lives after retirement.

Figure 4 : Changes in the Number of Allotment Gardens and Rate of Applications
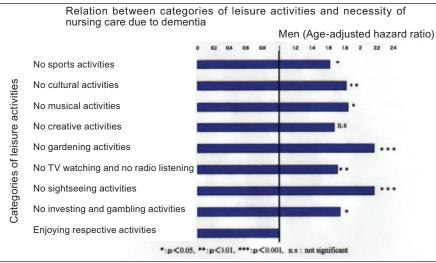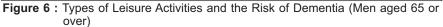
Source: Reference[8]

Note: Users include those who signed a use agreement and those who use the garden together with the former

Age group Prefecture	Younger than 30	30s	40s	50s	Aged 60 or over	Total
Ibaraki			1	6	20	27
Tochigi	1			4	6	11
Gunma			1	4	19	24
Saitama			1	8	22	31
Chiba			1	5	27	33
Tokyo	1	1	1	3	26	32
Kanagawa			1	2	26	29
Yamanashi		1	1	5	14	21
Nagano	1		2	8	20	30
Shizuoka				7	29	36
Total	3	2	9	52	209	275

Note: No response: 19

Figure 5 : Number of Users of Allotment gardens by Age Group

Source: Reference[9]

Figure 6 : Types of Leisure Activities and the Risk of Dementia (Men aged 65 or over)

Source: Reference[10]

4 Considering Employment Opportunities in Agriculture in Urban Areas

4-1 Rooftop gardening facilities have been increasing in urban areas

In recent years, from the viewpoint of reducing heat-island effects and seeking a qualitatively rich living environment, symbiosis with nature has come to be emphasized in planning and designing urban cities.[11] Under assistance systems by the national and various local governments, the total area of rooftop gardens has been increasing year by year. In 2009, nearly half of the total was in Tokyo, followed by Kanagawa, Aichi, Saitama, and Osaka. Rooftop gardens have thus increased, particularly in metropolitan areas.[12]

Backed by growing environmental awareness in urban areas, businesses that lend rooftop gardens on buildings have been prevailing in various parts in Tokyo, Takasaki city in Gunma, and Toda city in Saitama, as well as in Nagoya city and Osaka city. A survey conducted by the Ministry of the Environment for collecting examples of space greening showed that people now have larger opportunities to enjoy gardening in city life, with applications often in excess of capacity being made for rooftop gardens by people in a wide age range, from those in their 20s to those in their 70s.[13] People can enjoy casual gardening in rooftop gardens with less expertise and knowledge required, compared with farm work in allotment gardens. Rooftop gardens are usually located in accessible places, saving users the trouble of traveling, and utilities, such as water and electricity, as well as bathrooms, rest areas and other facilities are available nearby, as functions necessary for daily life are located intensively in urban areas.

4-2 Controlled environment agriculture is being commercialized on rooftops in urban areas in North America

In the U.S., agriculture in cities has attracted people's attention, with growing social needs for securing food safety, promoting local production for local consumption, guaranteeing food security, developing sustainable urban life, and creating jobs, etc. In February 2010, Brooklyn Borough compiled recommendations on a sustainable food system for New York City, in which rooftop agriculture was proposed.[14] Open-system agriculture by laying lightweight soil on rooftops was firstly promoted,[15] but greenhouse hydroponic cultivation is now being introduced. In Brooklyn Borough, a 15,000 square-foot ($1400m^2$) rooftop greenhouse is under construction and the first harvest is expected in June 2011. Eighty tons of vegetables and herbs are planned to be grown annually and be directly sold to local retailers and restaurants.[16] In Montreal in Canada, rooftop agriculture is going to start with further advanced control over the cultivation environment. In a 31,000 square-foot ($2900m^2$) facility, hydroponic cultivation and solid medium cultivation are carried out depending on crop types. Nutrients, water, light intensity, and temperature are controlled, and crops are cultivated all year round without the use of pesticides. Customer members have already been gathered locally and the first delivery is scheduled for April 2011.[17]

This type of agriculture, which enables stable year-round production by controlling the cultivation environment optimal to the growth of crops, is referred to as "controlled environment agriculture" in this report. Environmental elements necessary for the cultivation of crops are mainly light intensity, water, carbon dioxide levels, nutrients, temperature, humidity, and countermeasures against disease and pests, but if only stable production is ensured all year round, not all of these elements need to be controlled. In the case of Montreal, which is located in a high-latitude region, measures for summer heat are not necessary. They do not seem to control carbon dioxide levels, either, but this may be based on the consideration of ideal control levels by taking into account the business forms and production costs. Although the sustainability of the business needs to be assessed later, controlled environment agriculture in cities has thus become commercialized in North America.

4-3 Characteristics of controlled environment facilities as workplaces for the elderly

Elderly people's physical strength and health conditions vary by individual, and some healthy people may enjoy outdoor exercises in nature and prefer a farming environment where they can enjoy growing crops in spite of feeling some inconvenience. On the other hand, others may find it difficult to squat down to weed on hot summer days or may prefer to

do farm work indoors during the rainy season or on windy days. In controlled environment facilities, the temperature is usually maintained at around 22 to 25 degrees centigrade throughout the year, providing a comfortable working environment for workers. The workload is also relatively light. From the viewpoint of creating new communities where life in cities and life in rural areas can coexist, Mr. Masayuki Yamamoto, the writer of "Agri-Renaissance,"[18] states his opinion on controlled environment facilities as follows.

"In urban areas, for example, greenhouses for hydroponic cultivation can be constructed on rooftops of high-rise condominium buildings, schools, and public facilities. Hydroponic cultivation is a type of water-saving farming method, circulating a nutrient solution, and crops can be grown anywhere without soil if only there is sunshine, water, and electricity. Furthermore, being free from bad weather and low temperatures, it is very friendly to the elderly and children. As the environment is controlled by computer, and pesticides to avoid disease and pests are scarcely needed, nice and safe crops can be grown stably. Such farm work is most suitable for the elderly to maintain their good health and look for satisfaction in life… (the rest omitted)"

In controlled environment facilities, workers can engage in farm work in accordance with their physical strength, which may widen the range of the elderly who can obtain employment. As will be explained later in 5-1, controlled environment facilities are included in the category of plant factories. In the next Chapter, I will further consider the potential of controlled environment agriculture in cities for the purpose of providing employment opportunities for the elderly, based on the trends in studies on plant factories.

5 | Trends in Studies on Controlled Environment Agriculture

5-1 Trends in High-Tech Greenhouses

In recent years, high-tech greenhouses have come to attract people's attention again, due to incidents of foreign matter contamination of food, declines in food self-sufficiency ratios, and the upsurge of vegetable prices caused by bad weather. High-tech greenhouses are specific facilities that cultivate plants by controlling the growing environment (such as light, temperature, humidity, carbon dioxide levels, nutrients, and water),

where year-round planned production of vegetables, etc. is made possible through advanced environmental control and growth projections based on the monitoring of the environment and growth. High-tech greenhouses are roughly divided into two categories, i.e., those only utilizing artificial light, where crops are grown without sunlight under a closed environment, and those utilizing sunlight, where sunlight is utilized mainly in greenhouses, etc. with supplementary artificial light and with the help of technology to curb summer heat, etc.[19] (Figure 7). Controlled environment facilities explained in 4-2 are one type of plant factory that only utilizes sunlight or concurrently utilizes sunlight and artificial light.

High-tech greenhouses have various characteristics, as shown in Table 1, and can be designed flexibly, depending on priorities and combinations of elements and in accordance with use, into such forms as a highly-automated large-scale vegetable plant and a facility for the purpose of creating jobs. However, in any case, high production costs are one of the biggest challenges in diffusing plant factories[20] (Table 2). Depreciation costs of facilities account for 30 to 40% of the overall production costs, while out of the overall running costs, around 25% is utility costs and 20 to 30% is personnel costs.[19] These need to be reduced, while considering a balance suitable for the usage of each plant factory. Studies have been conducted in various fields, aiming to commercialize and disseminate high-tech greenhouses, concerning such themes as the development of optimal facility specifications and cultivation systems for specified crop types and the development of fundamental technology for integrated environmental control.[21]

5-2 Trends in studies relating to the employment of the elderly in controlled environment agriculture

There have been many studies related to the employment of the elderly in controlled environment agriculture, and by combining the results of such studies some effective business models can be described.

5-2-1 Low-cost facilities

If prioritizing job creation in carrying out controlled environment agriculture, the system needs to limit the level of automation and environmental control and leave processes that require manpower. Therefore,
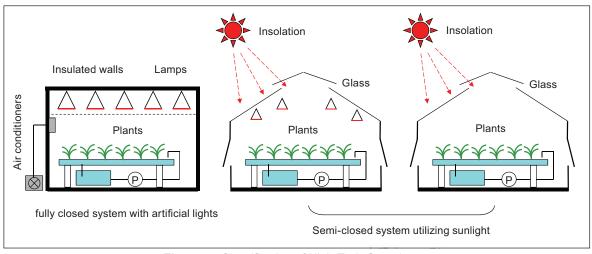
Figure 7 : Classification of High-Tech Greenhouses
Source: With consent of Prof. Eiji Goto (Faculty of Horticulture, Chiba University)

facility construction costs and running costs are mainly required to be reduced.

For example, the Horticulture Institute, Ibaraki Agricultural Center, and two private companies have succeeded in practical applications of a low-cost nutrient solution soil culture system with a capillary water culture system as its basis. The system can be built using various parts that are available from ordinary mass retailers, and attached facilities, such as a large tank for trickle filtering, are simplified. By growing plants in a plastic greenhouse on trial, the companies collected environmental information using a monitoring device and utilized it for cultivation management. This system may also be utilized at plant factories as it discharges little liquid fertilizer waste and works with less electricity.[22]

5-2-2 Production of high-value-added products

Controlled environment agriculture that prioritizes job creation cannot reduce personnel costs drastically. When it is difficult to maintain business although having sufficiently reduced facility construction costs and running costs, high-value-added products need to be produced. If one can grow expensive or precious crops in cities by fully utilizing the advantageous features of controlled environment agriculture, this will lead to coexistence with conventional agriculture.

At present, most of the medicinal plants are imports from overseas but it has become increasingly difficult to secure their sources due to expanding world demand for crude drugs and excessive harvesting. Recently, an industry-government-academia research group has succeeded in the hydroponic culture of licorice, and the stable production of licorice has become possible in a plant factory.[23]

5-2-3 Artificial soil

The hydroponic culture system is suitable for environmental control but types of crops to be grown are mainly limited to leaf vegetables. If stable soil culture is made possible in controlled environment facilities, root vegetables can also be grown and people may be able to enjoy touching and feeling soil in farm work.

Two private companies recently developed artificial soil with a high water and fertilizer retaining capacity by adding original technology to conventional peat moss. This soil facilitates a reduced frequency of watering, requires less water, and does not need top-dressing even when utilized for organic farming. Even with the use of organic fertilizer, the soil contains microbiological agents that are used for preserving food and can suppress the development of bacteria and mold. In the test plant, root vegetables, such as radishes, burdock, and turnips, and fruit vegetables, such as eggplant, okra, and pumpkins, are being grown.[24]

5-2-4 Development of a working environment for the elderly and the disabled, and verification of validity

Facilities for controlled environment agriculture provide a place for farm work just like citizens' allotment farmlands and rooftop gardens, but they all have different characteristics. It is necessary to verify whether controlled environment agriculture contributes to enhancing the quality of workers' lives by giving them a satisfied feeling.

Table 1 : Characteristics of Plant Factories

Production technology	・Comfortable environment in facilities, mainly light work ・Growth and quality being adjusted by environmental control ・Planned and stable production based on monitoring of the environment and growth and growth projections, instead of only depending on producers' instincts and experience ・Enhancement of nutrient components and functional components ・Reduction of the use of pesticides, fertilizer, and water
Sales	・High yield ratio of products for processing and for professional use, with less food loss ・Little contamination with insects or foreign matters, with cost reduction being possible by reducing washing and preparation processes ・A stable supply at fixed prices being possible even in cases of typhoons and other weather disasters
Location/Construction	・Can be constructed anywhere and enables agricultural production even at places other than farmland or at places not suitable for cultivation ・Can be installed even in vacant shops, vacant offices, vacant factories, and vacant warehouses (plant factories only utilizing artificial light) ・Highly efficient utilization of spaces by making multitiered plant beds (plant factories only utilizing artificial light)

Source: Reference[19]

Table 2 : Factors that Increase Production Costs of Plant Factories

Factors	Matters	Details
High facility costs (initial costs)	Dependence on heavily equipped facilities	High dependence on facilities that need to be equipped with environmental control systems and conveying devices in order to maintain year-round high efficiency production
	Inconsistent specifications with little past examples	Standardization of systems being difficult due to differences in factory scales and a limited number of constructions annually
	Heavy burden of depreciation costs	High rate of depreciation cost due to high facility costs
High running costs	High electricity expenses	High dependence on electricity, with electricity expenses constituting a large portion of the overall production costs
	Expensive plant materials	Cultivation containers, etc. with unique specifications being expensive
	Personnel cost	In spite of efforts for laborsaving, such as by introducing conveying devices, many processes require manpower

Source: Reference[20]

The R&D Center for Plant Factory, Osaka Prefecture University has been working to develop an optimal working environment in plant factories for the elderly and the disabled. With the participation of the School of Comprehensive Rehabilitation of the university, and the Universal Design Group of the Research Institute of Environment, Agriculture and Fisheries, Osaka Prefectural Government, it is scheduled to develop technology to measure the psychological effects that wheelchair workers receive from growing plants and to create horticultural therapy programs.[25]

5-2-5 Demonstration experiments on models of super-aging societies

Along with R&D of technology for plant factories, demonstration experiments on models of super-aging societies have been conducted. The Research Institute of Science and Technology for Society, Japan Science and Technology Agency, commenced new research on aging societies in FY2010, entitled "Redesigning Communities for Aged Society," which contains four R&D programs. In the program called, "Senior citizens' new career model in the community," a

demonstration experiment has been underway in Kashiwa city, Chiba prefecture, concerning a new society model where the elderly people play roles as supportive members.[26] Furthermore, a small-scale vegetable factory business is included in the seven business plans under said research.[27] In the private sector, a social model experiment is planned, aiming to reduce environmental load, cope with the problem of aging, and create jobs, and a vegetable factory is to be operated on trial for the purpose of providing employment opportunities for the elderly.[28] If a practical business model of a vegetable factory can be verified, this type of business is expected to be diffused in various regions, including urban areas.

5-3 Review of potential as business

When carrying out controlled environment agriculture on a rooftop, air conditioning is indispensable during Japan's hot and humid summer. There are several cooling methods, such as a heat pump cooling system, cold water cooling system, and evaporative cooling system,[29] but it is necessary to develop an optimal cooling system, while taking into account various factors, including effects, environmental control, and facility costs. Regarding job creation, in the aforementioned case in Montreal, eight to 10 workers are considered to be necessary for nearly 3,000 square-meters of farmland. A survey of eight plant factories concurrently utilizing sunlight and artificial light that are now operating in Japan revealed that there was less than three workers per 1,000 square meters in five facilities and three to five workers in two facilities.[30] Judging from these data, if a 1,000 square-meter controlled environment facility is constructed on the rooftop of a building, only around two persons can be employed. Therefore, it is necessary to develop a business model and a profitable structure that can ensure certain employment levels.

By using artificial light, crops can be grown indoors without sunlight. Not only rooftops but also other various spaces, such as vacant shops, vacant warehouses, and closed schools, can be utilized, which expands the options for installing facilities. A plant factory only utilizing artificial light in Chichibu city, Saitama prefecture, was constructed using a vacant factory building and the initial costs for starting operation were reduced to around half of those for ordinary facilities.[31] In the 400 square-meter factory, leaf vegetables are being grown and are directly sold

to hotels and restaurants.[30] Since its establishment in 2008, the factory has continued business by hiring as many as six workers. This business model may serve as a good example.

6 | Conclusion

Controlled environment agriculture is considered to have the potential to provide good employment opportunities for the elderly in urban areas in a super-aging society. Controlled environment agriculture makes it possible to utilize infused resources, such as water and nutrients, efficiently for growing crops. Soil, water, fallen leaves, and other waste does not scatter around, and crops can be cultivated without the use of pesticides. These are all advantages of controlled environment agriculture, which may be developed into a resource-saving type of agriculture suitable for an urban environment, and may promote local production for local consumption, creating a new flow of products and people in cities, as well as help the development of communities especially by encouraging the elderly to get involved by obtaining employment. In the future, we need to picture ideal business models and develop technology to realize them.

In the cases of controlled environment agriculture projects conducted on rooftops in North America, the objective is to create jobs in the relevant regions as a whole, instead of targeting only elderly people. Judging from the results of the survey targeting Tokyo citizens mentioned in 3-1 and the utilization study of rooftop gardens mentioned in 4-1, not only the elderly but other citizens of Tokyo in wider age groups seem to be interested in agriculture and gardening. Therefore, other than the elderly, young people and housewives, who once quit jobs for child rearing, may be included in those seeking jobs in the field of controlled environment agriculture in Japan. If the scope and influence of this type of agriculture expand to all urban residents, its social value will further increase and can be a successful urban model in a super-aging society. It is expected that other foreign countries, such as South Korea, Singapore, and Germany, will become a super-aging society by 2050,[32] and Japan's urban model adopting controlled environment agriculture may serve as a helpful reference for these countries.

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Profile

Kazuhito AKASAKA
Life Science Research Unit,
Research scientist, Science and Technology Foresight Center
(http://www.nistep.go.jp/index-j.html)

Kazuhito Akasaka has been in his present post since 2010, after having engaged in drug screening, protein expression and purification, as well as research on peptide, etc. at a pharmaceutical company. He is mainly studying research trends concerning overall life science, including medical care, health, and food. He is a Doctor of Medical Science.

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2

Standardization of Electronic Commerce in the Cloud Environment and Its Future Evolution

Akihiro Fujii
Affiliated Fellow

1 | Introduction—EDI in the Cloud Environment

EDI is an acronym for Electronic Data Interchange,[1] and is defined as the "means to represent a variety of documents—management, commercial, and transfer—using a set of structured alpha-numeric linguistic strings based on standardized rules."[2] The use of EDI enables enterprises to exchange transaction information with other companies in a more effective way.

EDI has been considered an indispensable element of business-to-business transactions. From the 1990s onward, as the availability of the Internet became more and more ubiquitous, much effort has been made in each sector of industries and in each corporate group to introduce Web-assisted EDI systems, and for the establishment and dissemination of common specifications.

EDI is essentially a tool for information sharing among different and dissimilar organizations. Therefore, cloud computing has gained attention in recent years because of its promise to usher in a new aspect in EDI dissemination.

This report first outlines the current trend toward EDI standardization, and then considers the changes that may be brought about through the use of the cloud environment. It also considers the involvement to be shared by the universities contributing to these changes.

2 | Standardization Trend of EDI

2-1 Roles of EDI in distribution channels

EDI is being used extensively to facilitate the flow of goods, and, although consumers seldom feel its presence in daily life, they very much enjoy the benefits it provides.

Let us first overview the role EDI plays when a consumer purchases goods from a manufacturer (see Figure 1).
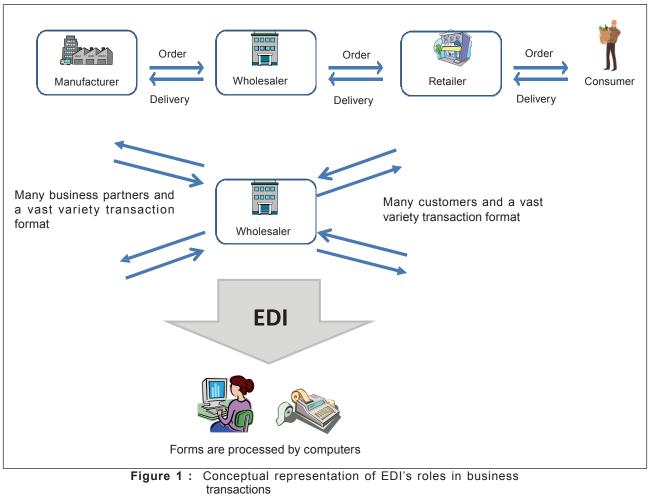
A product, after leaving the manufacturer's site, passes through several steps of distribution channels before it is delivered to you. To make the description simpler, we assume that the distribution channel consists only of three steps: a manufacturer, a wholesaler, and a retailer. A closer look at the transaction processes in the wholesale stage shows that an order from a retailer comes as an "order sheet." The product, in response to the order, is shipped with additional forms, i.e. a "delivery slip" and an "invoice." Each form must be processed in the relevant department of the wholesaler: the order information must be entered into the information system for retrieving the right product, and the invoice must be processed in the system in the accounting department. By the same token, these forms are utilized for managing the sales activities and expense control of the retailer, and the shipment management and production control of the manufacturer.

A wholesaler usually handles a variety of products from many manufacturers and does business with a host of retailers. Even in the highly simplified transactional case described above, many forms are exchanged many times among the customer, retailer, and manufacturer; information exchange represents the business transaction.

In the past, these transactions were processed using pens and paper. EDI is an information system that helps make information exchange for transactions smooth, and represents one of the application areas for cutting-edge information systems.

2-2 Standardization in EDI

What kinds of arrangements are required for the smooth exchange of electronic forms among the enterprises involved? To implement EDI for the electronic information exchange of transaction forms, the arrangements on such items as those listed in Table

Figure 1 : Conceptual representation of EDI's roles in business transactions

Prepared by the STFC.

Table 1 : Summary of EDI standards

Summary of EDI standards		
Technical items	Representation of information	・Message exchange format and its contents ・Protocol to control the exchange of electronic files
	Communication scheme	・Platform for information exchange ・Characteristics of electronic communication network
Management items	・Information contained in the service delivery (catalog preparation, order entry, payment, invoice, and logistics) ・Flow control scheme (purchase guideline, traceability of order flow, acceptance of goods, security) ・Management of electronic documents (archive management, search, backup) ・Legal liability management	

Prepared by the STFC.

1, as viewed from technical and management aspects will be required. These are broadly classified into technical arrangements and those from management considerations. The technical arrangements are further classified into two aspects: the format used for representing information, and the communication scheme.[2]

These arrangements can differ from one industrial sector to another. Therefore, an EDI implementation, if it is to be successful, calls for the enterprises in each of the industrial sectors to participate in planning a common standard. A typical example of success in early EDI introduction and subsequent evolution includes the banking sector and supermarket chains. The convenience we enjoy in inter-bank transactions using an ATM well exemplifies the results of EDI introduction. Convenience stores present another example, where information from cash desk operations is directly reflected in an EDI system. As seen above, the use of EDI has become a familiar experience in daily life.[10, 11]

Table 2 : Past international agreements regarding EDI implementation

Year	Description
1988	Formulation of EDIFACT by UN/CEFACT
1998	EDIFACT v.4 approved by ISO-9735
1999	UN/CEFACT and OASIS started developing ebXML
2004	OASIS ebXML acquired ISO-15000 accreditation
2004 -	Modification/update is being made to ebXML under the leadership of UN/CEFACT (e.g. addition of dictionary)

Prepared by the STFC.

2-3 Events leading to the move toward industry-wide common EDI standards

Although the types of forms handled by EDI may differ substantially from one industrial sector to another, the format used for representing information in communication and computers should be standardized on a cross-industrial and international basis. The common EDI standard, effective across business segments, is sometimes called a "meta-model." Standardization efforts have been made toward establishing a meta-model on an international basis.

The milestones in the history of developing international agreements for EDI are listed in Table 2. In the table, "EDIFAC1," "ISO-9735" and "ebXML" are the designations given to respective EDI standards. Each of these represents a document system that defines the details required to implement EDI, including, for example, the message exchange format described in the previous section. Of special importance, in the history of discussions toward the common standard, is the adoption of a standard generally called ebXML (Electronic Business using eXtensible Markup Language) on an international basis.

The ebXML represents a series of standards used to process inter-enterprise electronic commerce on the Internet, for which a language called XML (eXtensible Markup Language) is employed for description. The United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) and the Organization for the Advancement of Structured Information Standards (OASIS) jointly established the ebXML Initiative to start developing specifications, and the first edition of the major specification items was published in 2001.

The International Organization for Standardization (ISO) approved the ebXML specifications proposed by OASIS and UN/CEFACT, and published them in 2004 as a part of ISO/TS1500 ebXML.

2-4 Current status and issues surrounding EDI

The implementation of EDI in a specific business area requires, in addition to the adoption of an international standard scheme, detailed considerations and definitions on the concrete format of slips used in the area. In other words, a business-area-specific EDI is constructed on the basis of the meta-model. For example, a standard called RosettaNet has been established for the electronic parts segment.

The ebXML mentioned previously consists of multiple specifications, including "Message Service," "Business Process Specification Schemes," and "Core Components," providing a reference to define business-specific forms. Some forms are defined independently according to the commercial practice conducted in the supply chain and corporate affiliation of an enterprise.[4]

The introduction of EDI is expected to provide, by streamlining the supply chains, a huge benefit to each business sector and participating enterprise, but inter-enterprise electronic commerce has not necessarily achieved sufficiently widespread use. In the following sections, the author reviews the current state of affairs surrounding EDI, especially from technological viewpoints.

2-4-1 Current status of EDI diffusion

Among the enterprises in Japan that are affiliated with supply chains of large distributors and large manufactures, 80 to 90 percent of them have already introduced EDI. EDI usage in transactions among small- and medium-sized enterprises is much smaller, and the introduction ratio is estimated to be 10 percent or less.

A survey report published by Japan Information Processing Development Corporation (JIPDEC) in March 2010 ("A surveillance of utilization EDI/electronic tag application in Japanese industries")[3] summarizes the results of a questionnaire survey conducted on various enterprises from a wide

spectrum of industries and types of operations.

In terms of the penetration of EDI, 80.0 percent of the respondents replied that they use EDI "with some of the client companies," and 2.2 percent "with all of the client companies." EDI penetration showed a marked difference according to sales amount at a threshold of ¥1 billion. The EDI introduction ratio for enterprises with sales less than ¥1 billion was 45.9% (total of "partial" and "full" usage), but the ratio rose to 87.5% for enterprises with ¥1 billion or more in sales. A questionnaire concerning the reasons hindering EDI diffusion was made, targeting the enterprises that have not introduced EDI. The most common reason was the existence of an "established method (e.g. FAX) to communicate with business customers" (35.7%), followed by the "high cost of introduction" (28.6%), and "the lack of inter-industry standards, e.g. a standard EDI format" (25.0%). The EDI introduction ratio showed the same tendency when the sales threshold was increased to ¥2 billion and then to ¥5 billion.

The results described above show clearly that EDI penetration is higher in larger enterprises and is limited in small- and medium-sized ones. This tendency has also been pointed out by a variety of surveys and researches.

2-4-2 Multi-Terminal Phenomenon

Looking back on the past 20 years, although IT investment was strongly called for to streamline inter-enterprise business transactions, the investment for introducing a basis mechanism, typically EDI, has not necessarily been easy, especially for small- and medium-sized enterprises, due to limited financial resources. In concrete terms, the occurrence of the multi-terminal phenomenon has been one of the impediments, which causes problems including the following:

1) Because of multiple independent EDIs for contacting each business customer, the EDI operator has to switch from screen to screen (many Web browser windows).
2) EDI data is not always compatible with that of the existing in-house information system. The operator may have to re-enter the data manually.
3) The user is billed for each EDI and for each user ID.

The most important and labor-intensive process in EDI-system construction is to put a common standard in place, and to resolve the associated management problems in line with it. To the former aspect of the challenge, the widespread availability of the Internet and well-developed infrastructure for information sharing should have been a stronger tailwind for EDI, an electronic information sharing scheme. The fact of the matter, however, was that the efforts for establishing standards fell far short of the technical developments.

The Business Infrastructure Committee, set up by the Ministry of Economy, Trade and Industry (METI) in December 2008, described the situation around the problem as follows in its report issued in July 2009: "The straightforwardness of system construction promoted wide diffusion of EDI systems among many enterprises, including small- and medium-sized companies, which also prompted a proliferation of mutually-independent, incompatible standards," and "the underlying problem is that the basic mechanism of Web-EDI is most suited to remote controlling the information system of the enterprises that issue orders, and is not particularly suited to electronic data exchange, which is the bottom line of EDI."[5, 6]

As a specific example, let us review the approach taken by Company A, a midsize trading house handling mainly mechanical parts with yearly sales around ¥10 billion. As a wholesale operation, the volume of orders Company A accepts through Web-EDI from the customer retailers amounts to only 10 percent or less of Company A's total sales. On the other hand, the volume of orders Company A issues to the manufacturers using EDI amounts to nearly 50 percent of its total sales. The company uses ten types of Web-DI in daily operation. By the same token, it is normal practice for a retailer to use five to ten different types of Web-EDI. The situation described here is not specific to Company A, but represents a typical Web-EDI use within a business sector.

In many cases, enterprises introduce a Web-EDI system in response to the demand from their clients, who are larger business partners, although they know that the situation surrounding their own in-house information system does not allow overall coordination with such foreign systems, resulting in the need to set up several different EDI systems tailored on a customer-by-customer basis. This situation is what has been referred to as the multi-terminal phenomenon. In such an environment, to make a correct link to the in-house system, the operators have to work on many separate, customer-specific EDI screens/windows,

moving their attention from one terminal to another. Furthermore, EDI is generally a pay service. Because the majority of EDI users among small- and medium-sized firms have introduced it for facilitating order entry, they are charged on a flat-rate or pay-as-you-go basis. These factors constitute major obstacles hindering the widespread diffusion of EDI.

3 | Possibility of EDI Innovation: The Arrival of Cloud Computing

Cloud computing is considered to trigger a significant shift to the corporate information system, both in system providers (IT vendors) and system users (enterprises).

The following changes, from the viewpoint of EDI introduction, are expected to take place:
1) Lower initial investment for IT system introduction
2) Cloud computing providing the means to coordinate EDI-to-EDI differences
3) The arrival of new operational challenges to be resolved, typically the security problem
4) The construction of an open and cloud-compatible environment.

In concrete terms, the provision of software services is expected to shift more to a through-the-network scheme, and billing will be made on a pay-as-you-go basis, as the keyword "from ownership to access" well indicates.[12] By the same token, billing for hardware (e.g. servers) will also shift to a pay-as-you-go basis. As EDI functions are actually provided to the users as a software service, these changes will have a decisive impact on the future environment for the utilization of EDI.

3-1 Changes in Japan

To promote effective utilization of EDI, demonstrative experiments are being conducted under the initiative of the Japan Electronic Data Exchange Council (JEDIC) to develop ways to construct a low-cost, cross-industrial EDI system, while taking full advantage of existing industrial-sector-specific EDI systems. One of the large-scale demonstrative experiments intends to ensure interoperability between the electronic industry and motor vehicle industry. In the experiment, each of the sectors of Japanese industries implements its own industry standard EDI in compliance with the stipulations set up by OASIS. Reports have been released on the findings of the experiment.
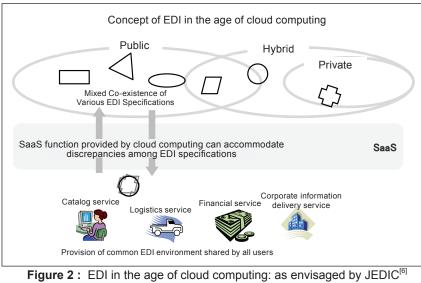
According to a JEDIC Newsletter,[6] JEDIC is now studying the ways to construct an IT-supported social infrastructure for informational economy, whereby a special emphasis is placed on "business infrastructure." The scheme aims at the sharing of information stepping across the bounds of individual economic transaction, which will become accessible by removing boundaries between enterprises, categories of business, and industrial sectors. In other words, the council is plotting cross-industrial EDI specifications that meet the requirements for desirable industry standard EDI, i.e. international and inter-industrial validity, and sound comprehensiveness.

Figure 2 shows a conceptual diagram of the cross-industrial EDI in the age of the cloud. Subsequent objectives for JEDIC include expanding the user basis of the cross-industrial EDI implementations, and providing such important information to industries as a common dictionary of EDI, and well-maintained and updated specifications of the cross-industrial EDI. In addition, JEDIC is geared to study the mechanism for efficient inter-enterprise information linkage in the evolving IT environment (i.e. the cloud), including standardization efforts and promotion activities for wider acceptance.

An important aspect of the information linkage mechanism is that all the information technologies to be adopted must be based on the cloud environment. According to a report titled, "Report on promotion of next generation EDI," and published by the Next Generation Electronic Commerce Promotion Council of Japan (ECOM) in March 2007, "progressive technological cross-fertilization with the next generation EDI standard technologies, including Web services (or Web API), will transform the existing mechanism for EDI function delivery into a new level of accomplishment, where bi-directional interoperability will become accessible much more easily."[20]

As an activity in Japan to ensure security in EDI, the National Institute of Information and Communications Technology (NICT) provides, in cooperation with Keio University, an authentification infrastructure that is a cloud-based application and still retains a research and development nature. Research and development activities centered on effective utilization of the cloud environment have been gaining momentum. For example, the Ministry of Internal Affairs and

Figure 2 : EDI in the age of cloud computing: as envisaged by JEDIC[6]
Concept of EDI in the age of cloud computing

Communications (MIC) gave the go ahead, in the 2010 fiscal budget, for municipality-based test projects to ensure data interoperability in the cloud environment.

3-2 Standardization in Other Countries[22]

In many countries other than Japan, standardization efforts, typically on EDI, are being carried out by public organizations. The approaches adopted in some of the countries are described below (they are not necessarily cloud-based).

In the USA, there is a standard called ASC X12. Data transmission in compliance with ASC X12 uses the security structure defined by X12.58 (published in December 1997). ASCX 12 also allows direct use of a standard certificate based on X.509, which is issued by a certificate-issuing organization. This mechanism allows the protocol to ensure security in terms of safe electronic transactions.

Korea is regarded by OASIS as the country most active in implementing ebXML. Government-affiliated organizations, such as the Korea Institute for Electronic Commerce (KIEC), are operating agencies dedicated to electronic certificate registration, which guarantee EDI security.

In China, the China National Institute of Standardization (CNIS) is playing a leading role in efforts to establish national registry organizations so as to realize e-government. A system of metadata for common use among ministries and agencies was developed, and it came into actual use. To provide infrastructure for promoting informatization among the government organizations, a registry-based system

development methodology was formulated and ordained by CNIS.

Standardization efforts of EDI in terms of metamodels are gathering momentum in China and Korea. Accordingly, the number of participants from these two countries in WG2 (metadata-related standardization) of ISO/IEC JTC1 SC32 ("Data Management and Interchange") is growing significantly in recent years, and a number of proposals for launching new sub-programs and study projects have been made.

3-3 Emergence of a new EDI that designates the cloud as its operational infrastructure

In the USA, some IT vendors have already begun to deliver software products that explicitly assume a cloud environment as the infrastructure on which EDI is operated. An IT vendor that has major players in the distribution industry in its customer list announced that it would introduce a cloud-environment-based inventory management and EDI system.[21] The system uses an independently defined standard, SuperSpec, to internally coordinate discrepancies among the varieties of existing EDIs (coordination is made on the cloud-side using the standard), and the functions required to implement EDI are delivered as SaaS (Software as a Service).

The Apache Software Foundation, the provider of Tomcat (a standard server function), is also studying similar technologies. Other undertakings include a protocol development called AMQP (Advanced Message Queuing Protocol), which is an attempt to define a standard protocol that guarantees safe and

rapid data exchange of business-related documents on the Internet. AMQP is now under review for polishing up, aiming at wide diffusion.[23]

3-4 Moves Toward Open Standards

Major cloud vendors have already delivered software products for inter-enterprise information linkage, and these have been coming into widespread use rapidly. A typical example is the supply chain management software provided by Salesforce.com. New types of cloud-based business software are not necessarily extensions of conventional EDI technology. It is of importance for the user to study what kinds of changes are brought about by cloud computing to the inter-enterprise electronic transaction schemes that have been developed on a conventional-EDI basis.

In conjunction with the offering of electronic business transaction environments from major cloud vendors, a possible problem called "lock-in" has gathered the greatest concern. If the market ascendancy of a particular vendor grows too dominant through widespread use of its electronic transaction environment, other software vendors fall into difficulties in providing their software products to the market.

To compete with the push from major cloud vendors, there is a growing voice calling for a more open standard that allows other IT vendors to engage in development efforts.

At present, major ASP businesses, such as Google, Amazon, and Salesforce.com, are providing cloud-related services to general users. Important services become available only through the use of the API (Application Programming Interface) defined independently by these major players. In the future, however, it is expected that API based on an open standard will find more widespread use in service delivery, as the ongoing efforts toward an open standard are supported by many NPOs and other organizations. The prominent view at the moment is that the situation will settle upon a loose combination of API sets that provide standardized functions and structures.[3] This trend is reflected in the active moves toward standardization, the latest information of which is summarized in the Wiki-style pages provided by Cloud Standards Coordination; at present, the activities of 14 organizations are reported. An investigative survey conducted by the Internet Engineering Task Force (IETF)—an organization aiming at promoting standardization of the Internet—pointed out a wider range of organizations, 38 in all, that could help boost the standardization efforts of the cloud environment. Each organization's major objective, scope, and track record are summarized in a report from IETF.

Figure 3 shows a conceptual diagram (a page from IETF's Web site) depicting the relations between cloud-related standards. The current scenario for the effective utilization of the cloud largely depends, as shown on the upper part of the diagram, on the services (and the associated APIs) provided by the major cloud vendors.

The desirable future utilization scenario of the environment is shown in the middle and lower part of
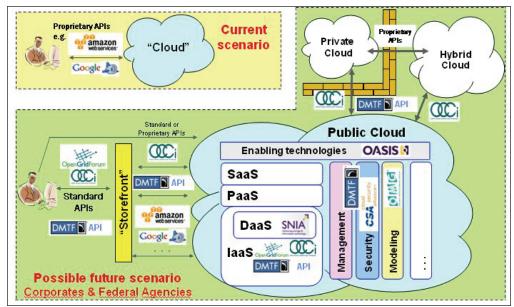

Figure 3 : Future scenario for cloud application

the figure. It is highly desirable that, with the help of the activities of standardizing organizations, the user is provided with an interface based on the common specifications defined by these organizations. In the diagram, the segment labeled "Storefront" represents the common interface that enables the standards-compliant vendors to deliver services; it is not entirely dominated by major vendors' proprietary API.

3-5 Participation from universities in the activities toward an open standard

In the USA, universities are actively concerned with establishing a cloud environment that is linked to electronic business transactions. It is generally considered that the cloud of the future will take a number of multifaceted forms, i.e. the combination of Public Clouds (the environment now widely used by such players as Google), Private Clouds (in-house environments operated by individual enterprises), and Hybrid Clouds. Under such circumstances, the types of services delivered by the providers undergo differentiation into some categories: SaaS (Software as a Service), PaaS (Platform as a Service), IaaS (Infrastructure as a Service), and DaaS (Datacenter as a Service). To ensure interoperability, standards that guarantee safe operational management and security have to be established in each of the environments.

A joint declaration regarding the future operation of the cloud ("Open Manifesto"[16]) was issued by 300 vendor-affiliated companies and US universities; they all support open standardization activities. The intended message of the declaration was to clarify that openness, and avoidance of "lock-in" by specific major vendors form the foundation for cloud evolution. In other words, the declaration intends to facilitate the transfer of data and applications from one cloud environment sponsored by a specific vendor to another environment. The declaration summarizes the common items required for a standard to be "open" (see the table below).

The Open Cloud Consortium (OCC) is a standardization organization established under the initiative of Illinois University (Chicago), with participants from academia and the private sector. The members from academia include Johns Hopkins University, Chicago University, Northwestern University, MIT (Lincoln Lab) and California Institute for Telecommunications and Information Technology (Calit2), while the members from the private sector—Cisco and Yahoo—support the project by providing relevant equipment and software development. The objective of the OCC is the standardization of technology that governs interoperability among dissimilar cloud environments, and the establishment of a framework relevant for its purpose.

Other than the organizations mentioned above, there is a variety of activities toward standardization.[17] One of the cloud computing standardization organizations in the USA, Cloud Security Alliance (CSA), released security guidance. The guidance organizes important points for ensuring security for an enterprise in making effective use of cloud services in 15 domains, including governance, law, and compliance.

In the USA, where business-academia collaboration is especially active in the IT sector, the universities are playing an important role in such standardization processes. In addition to the fact that it is easier for them to take a neutral stance in the deliberation processes for defining standards, they have the unique and importance merit of being able to present an evaluation from a purely technical point of view.

4 | Recommendations

As the introduction of cloud computing into IT-system construction progresses in many enterprises,

Table 3 : Items on which standards are required in conjunction with Open Manifest[16]

Item	Overview
Security	Of special importance in the cloud environment Transparency is required on the service-provider side
Data and Application Interoperability	A standardized interface is essential. The environment must be independent from the infrastructure and platform
Data and Application Portability	Interoperability is a must when the enterprise information system is subcontracted to an external agent
Governance and Management	Consideration of a cloud-specific operation scheme is required when subcontracting (e.g. system life-cycle management)
Metering and Monitoring	A consistent performance-evaluation metric is required: services from more than one cloud vendors may be used.

Prepared by the STFC.

the implementation cost for EDI may well become lower and lower. Much standardization effort is currently being made on the premise of widespread use of the cloud, and the standardization of EDI in a cloud environment is one of the key objectives in this trend. Some of the issues to be considered in conjunction with the EDI in the cloud age are as follows:

- Provision of common (ideal) EDI-compatible software for mission-critical tasks.
- Lowering of (initial) cost for EDI introduction
- Flexibility of EDI and the software running on it, capable of agile response to changes in the business environment of the enterprise
- Ease of participation in the EDI promoted by an industry group

When looking at the manufacturing-related industries, including the distribution sector, more than 90 percent of enterprises in Japan, such as trading firms, belong to the category of small and medium-sized enterprises. Problems, symbolized by the multi-terminal phenomenon described in 2-4-2, are taking place in such small and medium-sized enterprises. Therefore, in addition to the heretofore mainstream EDI systems, or those led by large companies, one of the future challenges is to introduce a new breed of EDI systems endorsed by the industry groups of small and medium-sized enterprises, in such a way that they fit well with the cloud environment.

From the viewpoint of software developers and vendors, cloud computing is expected to provide an innovation that enhances productivity significantly.[24] The cloud-based environment allows the relatively easy deployment of server-type applications, e.g. an EDI system. In another development, the progressively widespread use of handheld terminals may trigger a drastic change in the conventional enterprise information systems. In this way, cloud computing provides new opportunities for innovation in the software-provider side as well.

It is a generally accepted view that the small and medium-sized IT vendors in Japan are weaker in terms of market competitiveness than larger players. As already pointed out by the statistics and reports from Japan Information Technology Services Industry Association (JISA), this problem can basically be ascribed to a multiple-hierarchical subcontracting. Wide diffusion of cloud computing could provide such small and medium-sized IT vendors with a chance to

breakthrough into a new environment, enabling them to deliver important software products that support inter-enterprise electronic transaction.

The major cloud vendors at present are U.S.-capitalized large enterprises. Therefore, it is of special significance in Japan, especially in research activities at universities, to explore the possibilities of cloud-environment construction based on an open standardization.

Firstly, support for the diffusion of an open standard is important to ward off lock-in by a specific vendor. Along these lines, the research and development efforts must keep an eye on the new modality of EDI and electronic transactions, assuming the prevalence of the cloud environment, in which the matter of consequence is collaboration between the two groups of those involved: EDI users in small and medium-sized enterprises, and IT vendors that provide solutions for EDI and electronic transactions. In concrete terms, the accumulation of use cases, where the standard to be developed shell be applied, is important for facilitating standardization activities.

For example, the Distributed Management Task Force (DMTF)—one of the standardization organizations advocating open standards—has reported on nearly 20 of the practical research and development case studies around the world (e.g. U.K.) in the past two years. These kinds of feasibility studies can provide beneficial research materials for the practical application of business science and information technology.[20]

Even in EDI alone, academic-industrial collaboration, between a university and an individual industry group, could prove productive, whereby the university can provide a platform for experiments. The effort toward standardization based on the cloud environment is an ongoing process: the approach for the research should be reviewed and modified without delay in response to the changes in this trend.

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Profile

Akihiro FUJII
Affiliate fellow, Science & Technology Forecast Center
Associate Professor, Applied Informatics, Faculty of Science and Engineering, Hosei University
Akihiro Fujii (PhD in engineering) is, after years of research on distributed computing and communication protocols, currently engaged in a project for constructing an electronic transaction system. He is interested in the effects of telecommunication technology on the innovation in terms of business management and policymaking.

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3

Issues Surrounding Standardization and Promotion of Web Accessibility

Hajime YAMADA
Affiliated Fellow

1 | Introduction

With the advancement of an information society, there has been an increasing need for people to be able to access information. If anyone can access a piece of information, we say that the information is "accessible." In the case of website information, this quality is referred to as "web accessibility."

Web accessibility is typically targeted at elderly and disabled. However, it is not limited to these people. Smart phones are popular, but the small screens make them hard to use, even for young people without disabilities. In some cases, images on information terminals are not comprehensible without captions. Market evaluation of eBook readers is affected by the adjustability of text size on the screen. These examples suggest that web accessibility is not only for the elderly and the disabled, but that it is a factor in whether web technology-based equipment and services will be accepted in the market.

Countless organizations and individuals provide web technology-based content (hereinafter referred to as web content). There are also many kinds of web browsers to access web content. In addition, there are people who cannot see web content for various reasons and who use screen reader software to understand the content. Browsers and screen reader software are collectively called user agents.

If web content providers and user agent providers were to start using different technical specifications to respond to web accessibility, many users, including elderly and disabled users, would only be confused. Therefore, it would be desirable to establish a standard for web accessibility. In other words, the first step to promote web accessibility is to determine this standard.

This article introduces trends in standardization and activities to promote web accessibility.

2 | The Great East Japan Earthquake and Web Accessibility

The Great East Japan Earthquake occurred on March 11, 2011, and part of the Tohoku and Kanto regions were considerably affected. Public transportation was immediately disrupted, and since many power plants stopped working, planned power outages were conducted in many areas throughout the Kanto region.

Television and radio stations continued to provide special programs on the earthquake for more than a week. However, there was so much news to report that, in many cases, newscasters just announced that viewers and listeners should visit each company's website for detailed information, such as updates on public transportation and planned power outages.

Were people then able to access detailed information on each company's website? Could the browsers be used to expand text on the screens of those who had difficulty reading small characters? Was screen reader software working for those who were not able to acquire visual information? Were captions available for people who were not able to acquire audio information? The following section introduces some actual cases where problems were seen.

2-1 Case 1: Non-adjustable Text Sizes

On March 23, 2011, two weeks after the earthquake, I looked at how companies were providing earthquake-related information on their websites. In many cases, web accessibility was not given sufficient consideration. Figure 1 illustrates one such case.

Using Internet Explorer 7, I maximized and minimized the text setting on the website in Figure 1, but the size did not change at all. This is a typical scenario, where consideration is not given to web accessibility for those who have difficulty using small screens or reading small characters, including elderly users.
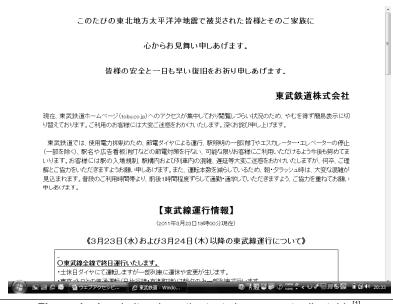
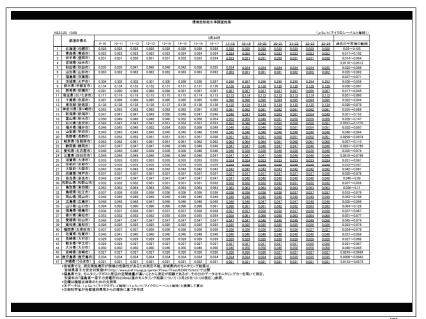**Figure 1:** A website where the text size was not adjustable[1]

Figure 2: PDF document not complying with screen reader software[2]

2-2 Case 2: Website Not Responding to Screen Reader Software

Documents on websites often employ Portable Document Format (PDF). However, if a PDF is just a scanned paper document, it does not contain text information and thus screen reading is not possible. However, as illustrated in the example below, there were cases where screen reader software did not work even though PDF documents contained text information.

The great earthquake caused accidents at a nuclear power plant in Fukushima prefecture, and many people were interested in learning about radioactivity. As such, the Ministry of Education, Culture, Sports, Science and Technology began releasing daily readings of environmental radioactivity levels by prefecture. Figure 2 illustrates the PDF document for readings. PC Talker Vista Ver.1.24 (screen reader software) read the beginning of the document as follows.

"Reading of environmental radioactivity level by prefecture, micro sievert per hour, nine, minus, ten, ten, minus, eleven, eleven, minus, twelve, twelve, ... usual value, one, 0.028, 0.028, 0.028, 0.028 ......"

"Nine, minus, ten" actually meant nine to ten o'clock. However, it was not explained that the readings were hourly results, and there was no text information for "o'clock," and so only numbers and minuses were

repeated audibly but incomprehensibly.

In addition, the "one" read after "usual value" meant the first observation site, located in Sapporo city in Hokkaido. The text "Sapporo city in Hokkaido" was on the PDF file, but the screen reader software skipped it for some reason. Therefore, for someone who could only listen to the information, it was not clear which observation site the document was referring to.

Next, the software read hourly readings, but it just kept reading numbers like "0.028." So it was difficult to understand important information, such as when the readings increased or decreased.

To solve these issues, it is necessary to read information in a manner that relates the heading (nine to ten o'clock) and the numbers like 0.028. As such, the reading of environmental radioactivity level by prefecture was hardly compliant with screen reader software.

2-3 Case 3: Partial Consideration of Web Accessibility

Almost every day, the Chief Cabinet Secretary had two press conferences per day to explain the government's response to the great earthquake. Videos of the press conferences have been stored on the Office of the Prime Minister's website, and anybody can watch the videos.

Figure 3 illustrates an image from the videos. A sign language interpreter can be seen on the left of the Secretary, and so the Secretary's speech can be understood in sign language. In addition, captions were added under the video screen.

It seems that the video gives full consideration to those who cannot acquire audio information. However, the question and answer session after the Secretary's initial speech is not captioned. Media reporters do not have microphones close by, so it is extremely difficult to hear their questions even for people without disabilities. There is also text information for the conferences, but it is limited to the Secretary's initial speech and does not include the questions and answers.

Except for those who are able to see and understand the sign language interpretation during the question and answer session, it is hard for viewers to fully understand the press conference.

In this case, it was necessary to provide captions during the question and answer session for both persons with hearing disabilities and those without. This case clearly exemplifies that web accessibility is not only for the elderly and the disabled.

At times like this great earthquake, in particular, websites providing public information play an important role, but web accessibility has not yet been given appropriate consideration.

In addition to the aforementioned cases, there were also many cases where only visual information was provided.

Figure 3: Insufficient captions[3]

3 | History of Web Accessibility Standardization in Japan

What needs to be done so that web accessibility is given consideration not only at times of crisis but also on a daily basis?

In Japan, the Japanese Industrial Standard (JIS) X 8341-3, "Guidelines for older persons and persons with disabilities - Information and communications equipment, software and services - Part 3: Web Content[4]" was published and has been used to this end.

3-1 JIS 2004 Version

JIS X 8341-3 was first published in 2004.

Those who plan and design web content should expect to have a wide variety of users with different needs, making the website accessible for different types of individuals, including elderly and disabled people. JIS X 8341-3 was published to provide a desirable technical standard for web content.

W3C (World Wide Web Consortium) plays a key role in the international standardization of web content. W3C includes WAI (Web Accessibility Initiative).[5] WAI released Web Content Accessibility Guidelines (WCAG) 1.0 in 1999. During the process of making JIS X 8341-3, the basic principle was to use WCAG1.0 as a baseline document. Additional technical specifications were also included to deal with unique situations in Japan. JIS X 8341-3 also conformed to JIS X 8341-1, "Guideline for older persons and persons with disabilities - Information and communications equipment, software and services - Part1: Common Guidelines," which was drawn up at the same time.[6] Accordingly, JIS X 8341-3 was finalized.

Incidentally, JIS X 8341-1 specifies accessibility technical specifications applicable to all information and communications equipment, software, and services. JIS X 8341-1 is, so to speak, the parent standard. Based on JIS X 8341-1, offshoot accessibility standards were created (8341-2: Information Processing Equipment; 8341-4: Telecommunications

Equipment; 8341-5: Office Equipment).

JIS X 8341-3 was created as part 3 of the JIS X 8341 series.

3-2 Japan's Contribution to International Standardization

After completing WCAG1.0 as the international standard, WAI at W3C began revising it to reflect rapidly advancing web technology. In response, Japanese experts began participating in WAI's work in around 2004.

One example of the technical specifications proposed by the Japanese experts was related to a technical specification surrounding a particularly prominent issue in Japan. Table 1 illustrates the case.

In Japanese, the same combination of kanji characters can mean different things depending on the pronunciation. For example, " 今 日 " means "today" when pronounced as kyô, but the same characters mean "nowadays" when pronounced as konnichi. Similarly, " 三 田 " can refer to either "Mita" city in Tokyo or "Sanda" city in Hyogo. In these cases, if pronunciations are not added in web content, it is possible that screen reader software will not pronounce the words correctly. It is not a big issue if the pronunciations are not visible to users reading visual text, but if screen reader software mispronounces these words, the words can have totally different meanings. Thus, JIS X 8341-3 proposes a technical specification: "… the pronunciation must be specified at the first appearance of the word." In fact, there are similar cases in other languages, too. For example, the English word "read" is pronounced differently depending on whether it is the present or past tense. As such, Japan's proposal was accepted, and WCAG2.0 added a technical specification: "a mechanism should be available for identifying the specific pronunciation of words…"

The discussion over WCAG2.0 faced difficulty, but it was finalized and officially released as the international standard in 2008.[7]

Table 1: Technical specification proposed by Japan for the international standard WCAG2.0

JIS X 8341-3 (2004)	Extensible use of words that may be difficult for the intended user to read (such as proper nouns) should be avoided. When such words are used, the pronunciation must be specified at the first appearance of the word.
WCAG2.0	A mechanism is available for identifying specific pronunciation of words where meaning of the words, in context, is ambiguous without knowing the pronunciation.

Taken from JIS X 8341-3

3-3 Revision of JIS X 8341-3

JIS standards are supposed to be revised every five years. So JIS X 8341-3 (published in 2004) needed to be revised in 2009. Accordingly, the revision work began.

The principle for the revision was to first conform to WCAG2.0. Web content can transcend national borders, and therefore, it is beneficial to have standards that are consistent with each other.

After it was published in 2004, JIS X8341-1 was proposed to ISO (International Organization for Standardization). Taking into consideration the opinions of experts from around the world, ISO 9241-20 "Ergonomics of human-system interaction - Part 20: Accessibility guidelines for information/communications technology (ICT) equipment and services" was published in 2008.[8] JIS X 8341-1 was revised to completely conform to ISO 9241-20 and to add test methods in an appendix. The second policy for revising JIS X 8341-3 was to reflect revisions of JIS X 8341-1.

In the revised version, individual success criteria are consistent with WCAG2.0. In addition, the revised version lists matters that need to be considered at each step: planning, designing, making, developing, verifying, maintaining, and managing. Test methods are also itemized in the main text.

After it was publicly reviewed, the revised version was published in August 2010.

4 Characteristics of 2010 Web Accessibility Standards

The 2010 version of JIS X 8341-3 has three major characteristics, and these characteristics affect the promotion of JIS X 8341-3. Each of the three major characteristics is described below.

4-1 Conformance Levels

JIS X 8341-3 divides 61 proposed technical specifications into three groups. These technical specifications are called success criteria in JIS X 8341-3. In this report, the technical specifications in the 2010 JIS X 8341-3 are called "success criteria," and in other cases, the term "technical specifications" is used. In addition the term "standard" means a document that is authorized by a standardization organization.

Table 2 illustrates the outline of the relationship between success criteria and conformance levels.

For example, to be recognized as level A, web content needs to conform to 25 success criteria. The success criterion for non-text content illustrated for this category is: "all non-text content that is presented to the user has a text alternative that serves the equivalent purpose…" The success criterion for the use of color is: "color is not used as the only visual means of conveying information, indicating an action, prompting a response, or distinguishing a visual element." These success criteria are for those who have difficulty acquiring visual information.

To be regarded as level AA, web content needs to conform to 38 success criteria. Thus, it is more difficult than being regarded as level A. For example, the criterion for images of text is: "if the technologies being used can achieve the visual presentation, text is used to convey information rather than images of text…"

To be regarded as level AAA, web content needs to conform to all 61 success criteria. In reality, however, it may be difficult to conform to every criterion. The success criterion for audio-only (Live) is: "an alternative for time-based media that presents equivalent information for live audio-only content is provided." This criterion is for those who have difficulty acquiring audio information.

Generally speaking, as already discussed, it is more difficult to be regarded as AA than A, and AAA is more difficult than AA.

The success criteria are categorized based not only on the levels of technical difficulty but also on the significance that affects accessibility. In other words, if web content lacks any of the success criteria to be regarded as level A, it seriously undermines accessibility.

Incidentally, the 2004 version did not have conformance levels. As such, there were cases where some web content claimed that they complied by selecting some technical specifications and conforming only to these self-selected specifications. The 2010 version does not allow this kind of picking of convenient criteria. Therefore, web content providers need to do their best to at least conform to the level A criteria.

4-2 Testability

The conformance levels do not work if one cannot verify the conformance of web content with the success criteria. In principle, the success criteria for

Table 2: Achievement criteria and conformance levels

Categories	No. of criteria	Example criteria
Achievement criteria for being regarded as level A, AA, or AAA	25	Non-text content
		Use of color
Achievement criteria for being regarded as level AA or AAA in addition to the 25 criteria above	13	Captions (Live)
		Images of text
Achievement criteria for being regarded as level AAA in addition to the 38 criteria above	23	Sign language (Prerecorded):
		Audio-only (Live)

Prepared based on JIS X 8341-3

the 2010 version of JIS X 8341-3 are testable. The following paragraphs illustrate some examples.

Flickering lights may trigger photosensitive epilepsy in some people. To avoid the triggering of photosensitive epilepsy, the 2004 version merely stated, "web content must avoid flickering on the screen at a high frequency." In contrast, the 2010 version clearly specifies the limit of frequency, stating, "web pages do not contain anything that flashes more than three times in any one second period…" This is a criterion for level A.

Elderly people with advanced cataracts have difficulty acquiring information on low-contrast screens. The 2004 version included the technical specification, "ensure that foreground and background color combinations provide sufficient contrast." The 2010 version specifies numbers for the success criterion for level AA, stating, "the visual presentation of text and images of text has a contrast ratio of at least 4.5:1…"

In addition, the 2010 version includes a testable success criterion for sounds (level A): "If any audio on a web page plays automatically for more than 3 seconds, either a mechanism is available to pause or stop the audio, or a mechanism is available to control audio volume independently from the overall system volume level."

The 2010 version did its best to eliminate ambiguous statements in the other success criteria and to pursue testability.

4-3 Technology Independence

Why did JIS X 8341-3 and WCAG need to be revised often? It is because web technology advances very rapidly and old technical specifications continue to become obsolete one after another. This is inevitable in the information and communications field.

To avoid frequent revisions, it is best not to mention specific technology in standard. Technology independence is an idea to draw up technical

specifications without mentioning specific technology.

The creators of the revised JIS X8341-1 and ISO 9241-20 (which was the base for JIS X8341-1) were conscious of technology independence. The same idea was adopted in WCAG2.0 and the 2010 version of JIS X 8341-3 as well.

In fact, the 2004 version of JIS X 8341-3 did not mention specific technical specifications in the main text. However, the version included many examples of how to respond to specific technology, and so the readers tended to feel that they were being encouraged to take specific measures.

For example, the 2004 version had a technical specification that stated, "provide equivalent alternatives to auditory and visual content." The standard was followed by the example, "… in HTML (Hyper Text Markup Language), use 'alt' for the IMG…" However, the example took on a life of its own, and adding the "alt" attribute for images was often considered a technical specification itself.

In contrast, as quoted in section 4-1, the 2010 version only states that "all non-text content that is presented to the user has a text alternative that serves the equivalent purpose…" Therefore, if new web technology allows mainstream methods other than the "alt" attribute to provide alternative information for images, it will not be necessary to revise the standard. For example, non-HTML technology such as Flash and PDF can be covered by the same success criterion.

5 Providing Technological Documents to Promote Web Accessibility

The 2010 version of JIS X 8341-3 is technology-independent, and so there may be those who do not know what kind of technology to implement to improve web accessibility. To help the needs of those who use the JIS standard, related technical documents and guidelines are now provided.

Table 3: Publicized documents related to the 2010 version of JIS X 8341-3

Documents related to JIS X 8341-3:2010
-Understanding JIS X 8341-3:2010 -Accessibility Supported (AS) User Agent Information -Test files required to create AS User Agent Information -JIS X 8341-3:2010 Test Guidelines -Compliance Performance Announcement Guidelines for JIS X 8341-3:2010
Translated documents related to WCAG2.0
-Web Content Accessibility Guidelines (WCAG) 20. -Understanding WCAG2.0 -Techniques for WCAG2.0

Source: Web Accessibility Infrastructure Committee of the Info-communication Access Council

The Info-communication Access Council established the Web Accessibility Infrastructure Committee (WAIC), and experts involved in the revision of the JIS standard gathered to work in the committee. Documents listed in Table 3 were finalized and publicized free of charge in August 2010.[9]

5-1 Accessibility Supported

Even if web content was created using technology that conforms to JIS X 8341-3, users cannot access the content if user agents such as the browser or the screen reader software do not respond to such technology.

Even if alternative text is provided for an image being used as a link to navigate to a topic, if a user agent cannot find the alternative text and show it to a user, the user will not see the image and will not be able to navigate to the topic. In other words, alternative text must be provided in a way that is understandable and usable for the user agent. Each user agent may require different technology to provide alternative text, and so it is essential to outline which technology complies with each user agent.

Access Supported (AS) User Agent Information provides a list to show which technology different user agents comply with.

5-2 Testing and Conformance Levels

Conformance levels illustrate to what degrees web content complies with accessibility. As discussed in 4-1, conformance levels are determined by whether web content conforms to each success criterion. How can one test whether web content conforms to the criteria?

As discussed in 3-3, JIS X 8341-3 has an article about test methods. Based on the article for test methods, JIS X 8341-3:2010 Test Guidelines illustrates detailed guidelines and examples on how to conduct a test.

There are tests both for a web page and a group of web pages. The test for the latter can be used for up to around 100 pages, but it takes substantial time and cost to test more pages. Based on the website's nature and web accessibility policy, it is necessary to examine and determine if it is reasonable to spend the time and cost to test all of the pages. For randomly selecting and testing pages to save time and cost, the appropriate number of pages required to determine whether the website passes or fails is 25 to 39, and checking 40 or more pages is definitely sufficient to determine whether the site passes or fails.

As such, JIS X 8341-3:2010 Test Guidelines illustrates detailed descriptions about how to conduct a test.

Compliance Performance Announcement Guidelines describes what kinds of tests are required to be able to announce that the website conforms to the standard. According to the guidelines, one can say that web content "conforms" to the standard if it is tested and found to meet all of the success criteria and, in addition, a self-conformance announcement is made based on the JIS Q 1000 "Conformity assessment - Guidelines for supplier's declaration of conformity with product standards." One can say that web content "mostly conforms" to the standard if it was tested and found to meet all of the success criteria. One can say that web content "partially conforms" if it was found to conform to part of the success criteria. One can say that web content was "tested taking consideration of the standard" if it was tested regardless of the results. One can say that web content "takes the standard into consideration" if the importance of web accessibility is taken into account, best efforts have been made to conform to the standard, but the content has not been tested.

It will be more convenient for users by referring to these conformance announcements.

6 Public Site Management Model Aims to Promote Web Accessibility Among Public Organizations

Among a great number of websites, public websites managed by the central, prefectural, and municipal governments, in particular, should be as easily accessible as possible by a great number of people. In particular, prefectural and municipal government websites contain necessary information for everyday life, and so it is critical to ensure their accessibility.

What kinds of principles should the heads of these governments propose regarding public websites? What should a website manager look for when placing an order with vendors? What should the manager be careful about when managing the website on a daily basis?

The Public Site Management Model (2005) answers these questions, and the revision work for the model began in September 2010 in response to the revised JIS X 8341-3 published in August 2010. The revision work for the model took account of opinions of prefectural and municipal governments, and the revised version was published in April 2011.[10]

The new management model advises that public entities, particularly prefectural and municipal government bodies, draw up web accessibility policies. The model also recommends that public bodies make their web accessibility policies available to the public on their websites and elsewhere. These web accessibility policies must specify concrete targets such as "Currently available websites must conform to conformance level A by the end of fiscal 2013, and conformance level AA by the end of fiscal 2014."

6-1 Systematic Efforts toward Web Accessibility

The Public Site Management Model recommends prefectural and municipal governments to systematically work on web accessibility.

Heads of public entities need to understand the significance of and the necessity for systematic efforts toward improving web accessibility, to establish and promote such efforts, and to take the lead in securing funding. Under the leadership of the head of a public entity, the department in charge of managing public websites works on accessibility. It is essential to secure a sufficient number of personnel and man-hours to manage the website as well as to provide the personnel with adequate training opportunities to understand the significance of and how to improve web accessibility. Public entities need to ensure that successors to these positions are appropriately briefed by predecessors as well as to educate the personnel to be experts in website management.

If several departments are in charge of updating web pages, it is essential to provide adequate training opportunities to all personnel involved. If a public body outsources the creation of a website or the development of a system, it is essential to hire a contractor who is knowledgeable about JIS X 8341-3 and to communicate intentions. It is important for the public body to take responsibility for setting goals and promoting the necessary steps to achieve the public body's goals rather than fully depending on the contractor.

To ensure, maintain, and improve web accessibility while taking into consideration users' opinions, it would be effective to ask for cooperation from local organizations of elderly and disabled to identify problems or to verify updated web content.

6-2 PDCA Cycle

The PDCA (Plan, Do, Check, and Action) cycle is critical for compliance with web accessibility policy. Figure 4 illustrates the PDCA cycle in the Public Site Management Model.

During the P (Plan) phase, the existing state of the site is determined and goals are established. To understand the existing state, accessibility assessment tools can be used, and experts who are knowledgeable about JIS X 8341-3 or actual users (including older persons and persons with disabilities) can assess the site. The current state of web management, including technology to create a site and methods to manage the site, is also recognized. Finally, a web accessibility policy is made and publicized.

At the D (Do) phase, efforts are made to achieve goals when creating and updating web pages on a daily basis. Additionally, these efforts are examined every fiscal year, and necessary personnel and budget are secured. For daily updates of a web page, the model suggests several ways to check accessibility: 1) the page creator can go through a list to identify any problems, 2) accessibility assessment tools or a CMS (Content Management System) can be used to identify any problems, and 3) web management personnel

who are knowledgeable about accessibility verify and publicize the page.

It is also important to include contact information on the website in order to actively collect users' opinions and to respond, on a daily basis, to any problems that can be dealt with swiftly. If there are problems that cannot be dealt with immediately, they can be examined and addressed the next time the site is updated in order to comply with accessibility.

At the C (Check) phase, test is conducted as discussed in section 5-2 (Testing and Conformance Levels), and conformance levels are publicized.

At the A (Action) phase, continuous action is taken to improve the web content quality by updating guidelines, providing training to personnel, periodically verifying web accessibility, and examining users' assessments. Based on the achievements made, more success criteria can be added, higher conformance levels can be set, or other revisions can be made in the web accessibility policy. Testing should be conducted based on JIS X 8341-3 at least once a year.

The Public Site Management Model is characteristic in that it advises public entities to repeatedly rotate the PDCA cycle. New information is updated on a website on a day-to-day basis, and so if the website is not managed continuously, web accessibility issues may occur without knowing. To avoid such issues, the model emphasizes continuity.

The Ministry of Internal Affairs and Communications

published an accessibility assessment tool called "miChecker" at the same time that the model was published. To check accessibility, there are tests that can be done mechanically and tests that have to be done manually. The "miChecker" conducts tests that can be done mechanically as well as helps determine results manually.

7 | Web Accessibility Code of Practice in the United Kingdom

To continuously improve web accessibility, BSI (British Standard Institute) has been working on a national standard called BS 8878 "Web Accessibility - Code of Practice." To maintain and improve web accessibility, matters to be systematically managed are covered in the standard in the form of a code of practice.[11] It is the same idea as the Public Web Management Model in Japan.

BS 8878 introduces three main reasons below that organizations should take action to improve web product accessibility and make it easier to use the products. Firstly for regal reasons: "if an organization's web product is not accessible to a disabled person, that person might have grounds for making a claim against the organization under the Equality Act 2010 or the Disability Discrimination Act 1995." Secondly, for commercial reasons: "the numbers of people who could benefit from more accessible web product … are significant. There are more than 11 million
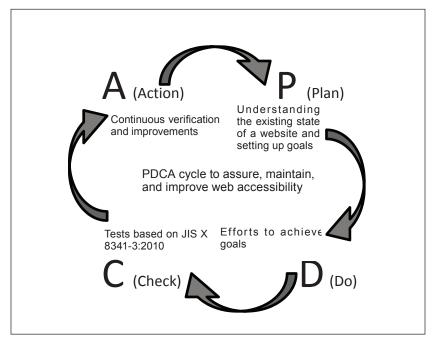

Figure 4: PDCA cycle recommended by the Public Site Management Model
Taken from the Public Site Management Model

disabled people in the UK, and there are nearly 12 million people of state pension age…" Thirdly, for ethical reasons: "Many organizations want to ensure that disabled and older persons are not excluded from (these) benefits and are able to use new technologies to increase their ability to live independently and to be fully engaged members of society."

BS 8878 uses the term "web products." Web products include any "website, web-service, web-based workplace applications which is delivered to users via Internet Protocol, through a web browser." The definition includes Rich Internet Applications, "Software as a Service" or Cloud computing services provided through a browser, computers, mobile phones, eBook readers, tablets and televisions. The definition suggests that web technology is widely used.

BS 8878 states that "as part of an organization's strategy for dealing with accessibility …, the organization should ensure that a department or specified role is responsible for the organization's compliance with BS 8878." BS 8878 applies to all types of organizations, including companies, non-profit organizations, government departments, local councils, public sector organizations, and academic institutions.

In contrast, the Public Site Management Model only targets public websites. To promote web accessibility, it will be essential for Japan to create documents that can apply to both public and private entities, including private companies and non-profit organizations.

In addition, BS 8878 specifies a series of procedures to be taken, starting with establishing web product purpose and analyzing the needs of target audiences. It continues to describe, in detail, how to assure accessibility throughout every process from web product designing, developing, and management. For example, BS 8878 describes user goals and tasks that the web product needs to provide, and the degree of user experience that the web product will aim to provide; inclusive design and user-personalized approaches to accessibility; delivery platforms to support; target browsers, operating systems and assistive technologies to support; the choice whether to create or procure the web product in-house or contract out externally; assuring the web product's accessibility through production; communication of the web product's accessibility decisions at launch; and assurance of accessibility in all post-launch

updates to the product.

The Public Site Management Model explicitly emphasizes the PDCA cycle. BS 8878 does not refer to the PDCA cycle even though it also advises organizations to continuously improve web accessibility. The PDCA cycle was proposed by Walter Shewhart and Edwards Deming, who established a quality control method after World War II. The cycle is also referred to as the Deming wheel. The quality control method is well known in Japan, but it is not widely recognized in Europe. That is why BS 8878 does not directly refer to the PDCA.

BS 8878 is a kind of process standard in terms that it governs operating processes in an organization.

8 | Accessibility Maturity Model

In the United Kingdom, the Employers' Forum on Disability organized the Business Taskforce on Accessible Technology and developed the Accessibility Maturity Model (AMM).[12] Using the AMM, organizations can self-assess and improve the accessibility of their information and communications-related systems, products, and services that they own or provide to society. The AMM also targets web content, as discussed in the following paragraphs.

Table 4 illustrates the self-assessment scorecard for the AMM.

An organization that has long been operating information and communications systems may be left with old systems (legacy systems). For example, if the accessibility in the legacy systems is low, the level is 1. If an improvement strategy is in place, the level is 2. If all legacy systems are made accessible, the level is 5. As such, organizations can conduct a self-assessment using the scorecard illustrated in Table 4.

Suppose that an organization self-assessed to level 2 under the "business drivers" and level 3 under the "standards and guidance" one year. Furthermore, when the organization has reassessed in the following year, the business drivers improve to level 3 and the standards and guidance remain at level 3. As such, progress is recognizable and further goals can be set. The strengths and weaknesses of an organization can also be identified.

The AMM can be used by an organization at various levels, including the Chief Information Officer, the Chief Technology Officer, the human resources department, and the IT program manager,

Table 4: Scorecard to assess organizations' IT accessibility maturity

Focus Areas	Level 1 Informal	Level 2 Defined	Level 3 Repeatable	Level 4 Managed	Level 5 Optimized
Business Drivers	No senior buy-in	Strategy in place	Top down commitment / involvement	Active strategy management	Pioneers and leaders
Standards and Guidance	Minimal or unclear	Basic standards documented / used ad-hoc	Standards in regular use / actively promoted	High standards / continuous improvement	Influencer / early adopter of new standards
Government & Risk Management Process	Not defined	Process defined / minimal actual governance	Active governance	Continuous improvement / strategic view	Suppliers influenced
Resources and Cost Impact	Not allocated or controlled	Some budget provided / clear responsibilities	Investment strategy / support services in place	Effective budget / benefit management	Specific funding for innovation / user empowerment
Delivery (design, build, test, implement)	Minimal inclusion in development lifecycle	Lifecycle stages requirements documented / applied ad-hoc	Fully integrated including Usability / Accessibility testing by staff and customers	Proven standards compliance / metrics collected	Innovation and design excellence
Procurement and Supplier Contracts	Minimal inclusion in procurement processes	Processes documented and used ad-hoc	Regular use including non-compliance management	Proactive and supportive	Supplier partnerships
Legacy Systems	Low accessibility	Limited legacy accessibility / Strategy in place	Priority legacy systems made accessible	Systems mostly accessible	All legacy systems made accessible
Reasonable Adjustments Process	Minimal / Reactive	Basic process used ad-hoc	Integrated process promoted and in regular use	Active management within service levels	Innovation / sharing of best practice

Source: Accessibility Maturity Model

to self-assess, understand, plan, and improve the organization's accessibility performance.

The AMM was created based on typical policies and activities that are common for both public and private entities. It reflects not only the opinions of the task force but also outside opinions. It characteristically suggests an indicator and direction of a comparative assessment and supports an approach to be taken by each organization to proceed to the next step.

9 | Efforts to Promote Web Accessibility

The Japan Web Accessibility Consortium (JWAC) was established in April 2010.[13] The Public Site Management Model only targets websites provided by public entities, but JWAC aims to improve accessibility on all websites.

JWAC conducts projects to maintain and improve web accessibility performance, to promote and provide education on web accessibility, and to conduct research activities for further improvements in web accessibility. Through JWAC activities, Japan is expected to establish a web accessibility code of practice and promote assessment measures equivalent to the Accessibility Maturity Model.

A private magazine company has been publishing website rankings for local public entities and private comapnies.[14] This can be an incentive and the announcement of the rankings is given a lot of attention. I hope that the rankings will reflect test results based on JIS X 8341-3.

The task force to promote administrative system reforms for disabled people (formed within the Cabinet Office) included ensuring information and communication access in its "Regarding basic direction" (published in June 2010).[15] The task force on ICT policy in the global era (formed within the Ministry of Internal Affairs and Communications) also proposes that public entities further improve accessibility of their websites.[16] As such, policies have been made to realize web accessibility. It is essential for both public and private website providers to heighten their awareness towards accessibility.

In the United States, public procurement has been based on Section 508 of the Rehabilitation Act since 2001. Section 508 requires the federal government to procure information and communications equipment and services that comply with accessibility technical specifications. To respond to rapid progress in information and communications technology, the revision work for the technical specifications in Section 508 began in 2006.[17] New technical specifications are expected to become effective in 2012, and the technical specifications for web content

are the same as WCAG2.0. In reality, therefore, web content provided by the federal government must conform to WCAG2.0. This is considered to help promote web accessibility in the United States.

This article explained the trends in the United Kingdom in detail, but some developed countries, including the United States, have begun to require web providers to respond to web accessibility.

10 | Conclusion

In Chapter 2, this article introduced some cases where web accessibility was not given sufficient consideration. According to the 2010 version of JIS, the level AA success criterion for text size adjustability is that "… text can be resized without assistive technology up to 200 percent without loss of content or functionality." The level A success criterion for a PDF document reader is that "information, structure, and relationships conveyed through presentation can be programmatically determined…" The level A success criterion for captions for videos is that "captions are provided for all prerecorded audio content in synchronized media…" If the websites discussed in Chapter 2 had been created and provided based on JIS X 8341-3 and had conformed to the abovementioned success criteria, the problems discussed earlier would not have occurred.

Disasters and other emergency situations often serve to highlight problems that have been overlooked. The Great East Japan Earthquake also shed light on many problems concerning web accessibility. Website providers must prioritize and work to solve such problems. It is more desirable to initially create a website that complies with accessibility than to later pay to fix problems that have come to light at the wrong time.

Problems that occur at times of crisis suggest that it is critical for an organization to always be aware of web accessibility when receiving and providing information. It is very likely that problems will occur if an organization tries to suddenly respond to web accessibility during an emergency. As I discussed in this article, I hope that the idea of creating standard processes will be widely accepted in order to systematically and continuously improve web accessibility.

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[8]   Information about ISO 9241-20 is on: http://www.iso.org/iso/catalogue_detail?csnumber=40727

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Profile

Hajime YAMADA
Affiliated Fellow, STFC

Dr. Yamada is a professor of the Faculty of Economics at Toyo University. He has participated in the task force on ICT policy in the global era (Ministry of Internal Affairs and Communications) and the task force on strategic international standardization at the Intellectual Property Strategy Headquarters. Dr. Yamada has been an active speaker on public policies and institutional systems in an information society.

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4

Robust and Usable Media for Communication in a Disaster

Tsuneo Ichiguchi
Information and Communications Research Unit

1 | Introduction

In the event of a large disaster, what we need first is the right piece of information. What happened? What was the scale? What should we do? Where should we evacuate? Such information should be provided immediately without a moment's delay. It is also important to provide additional information on the event after the instant communication.

The necessary information varies over time. The next thing we need to know is information about safety confirmation of family and friends. After the Great East Japan Earthquake on March 11, TV broadcasts showed us the images of people who wandered from one shelter to another, looking for the information on their missing family members. For victims of disasters and the persons involved, information on the extent of damage and the safety of their family members or friends is much more important than infrastructure such as electricity and water, or food and heating. Of course, various types of information on the refuge life become necessary when the evacuation is prolonged.

In the past, detailed reports and suggestions about information infrastructure at the time of disasters were published after the Great Hanshin-Awaji Earthquake (1995) and Mid-Niigata Prefecture Earthquake (2004). Following the Great Hanshin-Awaji Earthquake, information volunteer activities related to the opening and management of a local FM mini-station exclusively for refuge life was reported as a new movement.[1] After the Mid-Niigata Prefecture Earthquake, it was pointed out that the problem of digital divide was being experienced, due to aging and depopulation in mountainous regions.[2]

Previous reports, however, may not be directly applicable to the Great East Japan Earthquake because the enormity and extensiveness is incomparable with the past disasters and the worst damages were caused by the tsunami. Especially, we saw new plugged-in movements to utilize social media, such as Twitter and websites, and to keep tentative collaboration between TV broadcasts and the Internet.

A number of detailed progress reports on information infrastructure in the Great Earthquake of March 11 will be released in the future. Therefore, in this paper, I would like to describe how people received information and what kind of new media were used immediately after the Great East Japan Earthquake, and then examine their characteristics and advantages.

2 | With What Means People Obtained Information

2-1 Disaster radio system

We have witnessed, through TV broadcasts, speakers of the disaster radio system (formally called "Municipal Disaster Prevention Administration Radio Broadcast System") urging people to evacuate in a tense voice, while the tsunami was surging on the Pacific coast of the Tohoku district. For many people in disaster areas, who were working in fields and fishing ports, this disaster radio system was the only means to get the warning of danger. In the event of emergency, a simple and clear vocal evacuation order is effective.

After the 1960 Chilean tsunami, all of the coastal municipalities in Iwate, Miyagi, and Fukushima Prefectures were equipped with a disaster radio system. Although the system was broken down by the tsunami on March 11, there is no doubt that many lives were saved thanks to the disaster prevention personnel who used this system and kept calling for people to evacuate. The message was sent from municipal offices or fire stations, many of which were devastated by the tsunami.

Disaster radio system is now in the transition from analog to a digital wireless system.[3] However, for the sake of safety of disaster prevention personnel, it is

more important to construct an automated, unmanned, and remote-controlled system for emergencies, and to create a network with neighboring municipalities.

Because the tsunami disrupted communication cables, destroyed base stations of mobile phones, and caused power outages, there were many places where the only means to receive information was battery-operated radio. It became impossible for people to send out critical messages such as a request for rescue; on TV we saw the letters "SOS" written on the ground or rooftop of shelters, trying to send messages to helicopters flying over the area the day after the earthquake.

2-2 The Internet

In the metropolitan area, power outages or damage to communication facilities did not occur, but land-line or mobile phone services and texting on mobile phones became practically unusable. Information on the earthquake and tsunami was sent through TV broadcasts and the Internet. Many office workers were not able to watch TV, but they could watch TV news simulcast on the Internet. Because Internet connection was available as usual, social networks such as Twitter, Facebook, and Skype, were utilized as means of communication, to prevent the confusion among a vast number of stranded commuters. The Internet was connected to the world through a detour path of optical undersea cables, and transmitted real-time information on the disaster toward the rest of the world.

About half of the base stations of mobile phones in disaster areas were recovered on March 14, three days after the earthquake. Temporary mobile base stations and satellite phones using communication satellites were installed in shelters as well. However, mobile phone services and text messaging continued to be unusable because of overloaded lines, so social networks still played main role in communication. By that time, safety confirmation of victims became the most important information for their family and friends. Once the number of victims reached into the tens of thousands, it was almost impossible for mass media such as TV to collect and transmit individual safety information. It was also difficult to search for safety information from lists of names tacked on the wall of shelters scattered all over the devastated areas. Then people started a new approach on the Internet: first they accumulated and integrated information

on the web, processed it in a user-friendly way, and transmitted it. A number of information volunteers joined this new approach.

Thus, Internet infrastructure was both the most robust and useful at the time of disaster. In the next section, I would like to discuss more concretely why social networks using Internet connection were so robust during the disaster and what kind of new attempts were made.

3 | Internet Infrastructures Robust in a Disaster

3-1 Telephone lines and Internet connections

Since the electricity did not go out in the metropolitan area, TV and the Internet became the important sources of information. However, land-line or mobile phone services and texting on mobile phones became practically unusable, although there was no substantial damage on exchange equipments of telecom companies or base stations of mobile phones. Such a condition where telephone connection is cut off or text messages cannot be sent or received is called "network congestion". Once the congestion reaches its limit, the communication system as a whole goes down, so telecom companies take measures to limit the connection. In case of telephone services, you would hear the message, saying "The number you have called is congested and is not available now," and the line won't be connected.

Network congestion at the time of disaster is caused by the concentration of phone calls or text messages to confirm someone's safety, but the congestion can happen in other occasions, too; for example, telephones can be congested at the start of ticket reservations or for "A Happy New Year Call" from around midnight to 2 a.m. on the New Year's Day. After this earthquake, 80 to 90 % of voice calls and 50% of text messages were not connected.

Compared to telephone calls and text messages between mobile phones, communication via Internet connection, such as Twitter or e-mail between a mobile phone and a personal computer, were available almost as usual in the metropolitan area. Of course, the Internet was functioning as usual. Also, means of communication that use Internet connection, such as Skype, functioned as usual, too. Thus, in the recent disaster, there was a major gap between the communication means that linked to Internet

connection and those that did not.

While mobile phones are connected within a closed network inside a cellular carrier, the Internet is connected through several open lines and routers for routing information packets (See Figure 1). Even if a line is cut off somewhere or a router is broken down, the line will be connected again by bypassing the location automatically and information packets can be always sent and received. Therefore, congestion rarely happens; on the other hand, however, it is difficult to control the network traffic even if we want to.

The origin of the Internet is "ARPANET" developed by a military-related research institute in the United States. It was designed not to cut off the communication link even when telecommunication lines and bases were attacked. Thus, from the beginning, the Internet has robustness at the time of emergencies such as disasters. Renesys, an international internet intelligence company, has reported that out of 6,000 network nodes[NOTE 1] in Japan, only about 100 nodes stopped the service temporarily, but recovered within hours.[4]

The Internet's robustness at the time of disaster seems to have been proved, but we cannot necessarily say that congestion will never happen. When a number of accesses are concentrated on a particular homepage, the access to the homepage server will become impossible or the server will go down. After the earthquake, homepages of railroad companies and Tokyo Electric Power Company could not be accessed

on several occasions. Although the Internet is robust over a disaster, it also is vulnerable to malicious and intentional attacks because of its lack of perfect controllability.

3-2 Optical undersea cables

One of the characteristics of the Internet is that it is connected to the worldwide networks through optical undersea cables, so we can communicate with people in foreign countries in real time. Ibaraki and Chiba Prefectures, stricken by the recent disaster, have many landing stations of undersea cables; for example, there are landing stations in Kita-ibaraki, Ajigaura, Chikura, Maruyama, Wada, and Emi. Many undersea cables are concentrated in the offing of this area, and some of the cables go directly over the epicenter of the earthquake. Actually, undersea cables were damaged in multiple spots in this region, and it is supposed that there are three disrupted sections off the coast of Ibaraki, six off the coast of Choshi, and one off the coast of Kanagawa.

Undersea cables can be damaged not only by disasters but also by sharks and other causes, so repair work is operated by robots on a routine basis. Consequently, undersea cables as communication infrastructure do not have a point-to-point connection between Japan and foreign countries, but make a loop connection to secure a detour.

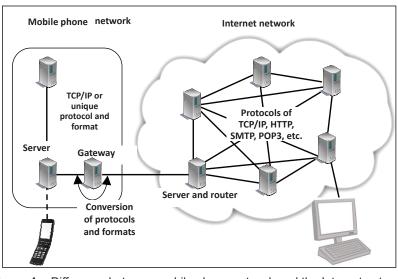For example, the optical undersea cable, Pacific Crossing-1 (PC-1), has a loop connection between

Figure 1: Difference between mobile phone network and the Internet network
Prepared by the STFC

[NOTE 1]
In accurate terms, it is "the network prefixes in the global routing table", but the term "network node" or simply "node" is used in this report. See Ref. 4 for details.
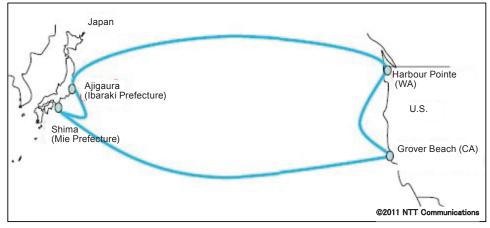
Figure 2: Route diagram of optical undersea cable Pacific Crossing-1.

Source: Cited from Reference 5

Japan and the United States with four landing points: Ajigaura (Ibaraki Pref.), Harbour Pointe (the State of Washington), Grover Beach (the State of California), and Shima (Mie Pref.), as is shown in Figure 2.[5] Also, Japan-US Cable Network connects Maruyama (Chiba Pref.), Kita-ibaraki (Ibaraki Pref.), Manchester (the State of California), Morro Bay (the State of California), Makaha (the State of Hawaii), and Minami-shima (Mie Pref.) in a loop. APCN2 (Asia-Pacific Cable Network 2) has Kita-ibaraki (Ibaraki Pref.) and Chikura (Chiba Pref.) landing stations in Japan, and connects Japan, South Korea, China, Taiwan, Hong Kong, the Philippines, Malaysia, and Singapore in a loop. There is also an undersea cable that goes around Japan along the coast.

Each loop network is mutually connected, so even if one of the networks breaks down, communication will remain possible through another network. Especially, Ibaraki and Chiba Prefectures were nodes of the loop networks connecting Asia and the United States, and had been functioning as a telecommunication hub in Japan.

At the time of earthquake and afterward, although the northbound cable was damaged, the Internet was able to connect Japan and overseas countries as usual, using the southbound detour. It is significant that the Internet could be used as usual, allowing the information on the earthquake transmitted overseas without delay. Actually, other Asian countries, such as Hong Kong and China, which had a connection to APCN2 and Japan-US Cable Network at Ibaraki and Chiba Prefectures, suffered poor connection to the United States; however, their connections were restored after being switched to another route on the next day. The Taiwan Earthquake in 2006 caused

serious damage to undersea cables, and services of telecommunication carriers were stopped for a few days after the earthquake. However, each country could avoid such a situation after the earthquake on March 11.

It was an effective risk avoidance that landing stations of undersea cables were build in Western Japan as well. The robustness of Internet infrastructure in Japan was praised throughout the world because the internet kept operating and supporting the communication both at home and abroad, in spite of the scale of the disaster.[4]

3-3 Restoration activities of each mobile-phone carrier and satellite telephones

Thousands of mobile-phone base stations were damaged in disaster area, and communication with the outside became impossible for many people. The number of broken base stations was as many as 6,720 for NTT Docomo, Inc., 3,786 for Softbank Mobile, Corp., 3,680 for KDDI Corporation, and about 2,000 for UQ Communications Inc. On March 14, three days after the disaster, about half of the broken base stations of each carrier were restored. However, recovery of official municipal websites took a long time, and many municipalities used Twitter and Facebook as a means to send their residents the information on evacuation centers and delivery of relief supplies

While mobile-phone carriers hurried to restore the base stations, they also tried to ensure communication means by setting up mobile base vehicles and portable generators at affected municipal offices and evacuation shelters. For instance, NTT Docomo, Inc. provided 900 units of satellite phones, and Softbank Mobile, Corp. installed the access point combined
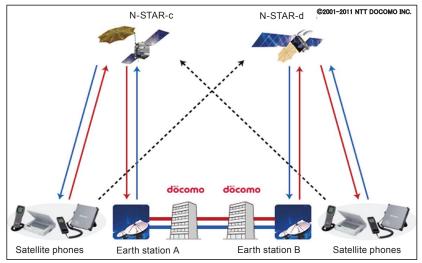
©2001–2011 NTT DOCOMO INC.

Figure 3: Outline of satellite phone service

Cited from Reference 6

with a satellite antenna so that people can use mobile phones in shelters.

The telephone service using a communication satellite covers wide areas with a few ground facilities; so we may say that it is a communication infrastructure robust in a disaster. The "Widestar" satellite phone service has been commercialized by NTT Docomo, and it covers the whole of Japan and about 200 nautical miles from its coast, providing voice and packet communications. The service started in 1996 to replace ship telephone service that used coastal base stations. The satellite phone is used at lodges in mountainous regions outside of cellular service area as well. Widestar was transferred to Widestar II in April 2010, and the speed of packet communication was accelerated from 64 kbps to 384 kbps at the maximum.

Widestar phone service is established via one of the two communication satellites, N-STAR-c (located at 136°E.) and JCSAT-5A (or called N-STAR-d by NTT Docomo: located at 132°E.); both are in a stationary orbit above the equator. The service is available anywhere in Japan and its off-shore areas, providing that the satellite is visible without obstacles. It is, however, necessary to set up an outdoor antenna in order to use the service indoors.

Satellite earth stations are located in Sayado Station (Midori, Gunma Prefecture) and Yojigata Station (Kitaibaraki, Ibaraki Prefecture), where the satellite phone connects to the telephone and Internet networks. Two satellite phones are connected to each other by making two round trips between the earth and satellites, such that satellite phone → satellite → earth station → satellite → other satellite phone.

They have two earth stations and two communication satellites for risk avoidance, so that the infrastructure can be maintained even if one is damaged in a disaster.

Satellite phones are also installed in many public facilities, such as hospitals, to prepare for possible disasters. It has been reported that satellite phones were useful for affected hospital to place an order for necessary medicine. Some Widestar phones are equipped with emergency lines separated from the lines for general use, and have been introduced to some municipalities, police stations, and fire stations. There is a move for some private companies to introduce them as disaster countermeasures as well; however, since there are a limited number of lines, congestion may occur if the service becomes popular.

4 | Effectiveness of Social Networks

4-1 Twitter as a means of communication

Twitter and Skype kept their robustness in a disaster by connecting them to the Internet through gateways, even if handsets of cellular carriers are used. These applications are available on smart phones that can access the Internet directly or via public Wi-Fi service at fast food restaurants, hotels, and stations.

This disaster revealed the public usefulness of Twitter, which enables us to communicate through the Internet. As a result, governments and public organizations started to use it. For example, the Prime Minister office set up an account "@Kantei_Saigai" for disaster information, and began transmitting information on March 12; the number of Tweets was 587, and the number of followers was 321,557 by April
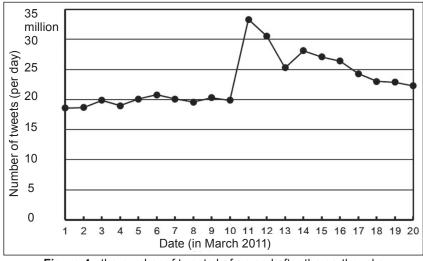
Figure 4: the number of tweets before and after the earthquake
Source: Prepared by the STFC based on Reference 7

11, a month after the earthquake. The office launched an English Tweet at "@JPN_PMO" on March 16, and started providing information to other countries through Facebook as well. The Twitter account of Fire and Disaster Management Agency "@FDMA_JAPAN" had been established in May 2010, and followers of the account increased rapidly after the disaster. The Japan Ground Self-Defense Forces also tweeted about their relief activities at @JGSDF_pr.

Unlike the traditional e-mail or blog, information through Twitter grows exponentially by means of official or unofficial re-tweeting. An enormous volume of information on the disaster has spread, and it was reported that the number of tweets on March 11 reached about 33 million in total, which was 1.8 times the average[7] (Figure 4).

When the volume of information gets so large, it becomes important to organize a lot of information or to search for information. On its official Japanese blog of March 12, Twitter, Inc. called for the use of unified hash-tags organized by topics and the use of official re-tweeting, not unofficial ones.[8] A hash-tag is a code to add at the beginning or ending of a message, in order to make classification and retrieval of information easier. Various kinds of hash-tags were provided and they could be used alone or combined; examples of such hash-tags are #jishin (information on the earthquake in general), #j_j_helpme (rescue request), #anpi (safety confirmation), #311care (information for medical staff), #311sppt (information from victims who need support), prefecture-specific information such as #save_miyagi, and life-related information such as #takidashi (provision of cooked food). Twitter provided the hash-tags needed in the

metropolitan area as well, such as #318teiden (power outages on a certain date) and #318train (train schedule on a certain date).

Under these circumstances, more than 200 volunteers extracted and categorized about 4700 Tweets tagged with #anpi in four days. Since Twitter is a free service that is flexible and open to the public, information volunteers can get together easily and respond quickly and adequately to the information. Such an advantage of Twitter was fully utilized after the occurrence of the disaster.

However, the system has its demerits as well because of its openness to the public; that is, inaccurate information and false rumors can be circulated easily. This time, too, some wild rumors were circulated such as: poison gas was leaked from the oil refinery that burst into flames in Chiba Prefecture, or it is effective to take mouthwash to prevent health damage from radioactivity. Nevertheless, quick transmission of information and the power of collective intelligence led to the immediate dismissal of these false rumors. Also, linked URLs in Tweets often included the sites of NHK, the Asahi Newspaper, and the Tokyo Electric Power Co., which indicated that people had a tendency to transmit useful information by collecting various kinds of information and combining it with press reports.[7]

In the metropolitan area, no buildings collapsed after the earthquake and power outage or water outage did not happen. However, the railroad system was stopped, and almost all lines did not recover before the next morning because of the continuous aftershocks; it caused a huge number of stranded commuters. At 7 pm on March 11, 3,000 to 4,000 people were

stranded around each terminal station of Shinjuku, Shibuya, Ikebukuro, or Akabane. They had to wait long time to get a bus or taxi. According to the count of the Metropolitan Police Department, the number of stranded commuters around major railway stations and Haneda Airport reached about 27,000.

At 8 pm, the government issued instructions to all government agencies to fully utilize their public facilities as shelters. The Tokyo metropolitan government also offered its community centers and schoolhouses for stranded commuters. Vice Metropolitan Governor Naoki Inose posted information on Twitter about available shelters. At 9 a.m. on the next day, he reported that about 99,000 people were accommodated in 1,023 facilities in Tokyo. Several universities and private facilities accepted stranded commuters as well, so the real number of stranded commuters is assumed to be much larger than reported. Moreover, there were tens of thousands of people who tried to walk home.

Since the earthquake caused little damage to the metropolitan area, the confusion did not grow out of control. However, if an epicentral earthquake occurs in the capital, it is estimated that the number of stranded commuters will be 3.9 million in Tokyo, and 6.5 million in Tokyo and surrounding three prefectures.[9] Therefore, it is an important issue to ensure communications means in emergency situations as well as to prepare a number of evacuation shelters quickly.

4-2 Real-time map of evacuation shelters in the metropolitan area

In the metropolitan area, as evacuation shelters for stranded commuters were announced, volunteers began to plot the physical locations of shelters on a Google map. Thus, a real-time map of evacuation shelters had been made and offered to the public. Figure 5 shows the real-time map as of 10:30 p.m. on March 11.[10] The map not only indicated the location of shelters, but also showed the detailed information of shelter about the capacity, emergency supplies such as blankets, drinking water and food, if the plotted mark was clicked. As time went on, the number of plotted marks on the map increased rapidly.[11] (See figure in page 6.)

They asked people who could use Twitter to tweet the information about evacuation shelters marked on the real-time map to as many people as possible. In this way, information discretely announced by Tokyo metropolitan government, the government of Japan, or each evacuation center was accumulated on a Google map first, and then, starting from there, transmitted through the means that people routinely used. Here again, the Internet and Twitter were naturally connected, providing a place for volunteers to establish a broad network.

For users, it is difficult to use information sent out from various sources discretely. Also, even if information about evacuation shelter is announced,

Figure 5: Real-time map of evacuation shelters (As of 10:30pm, March 11)
Source: Cited from Reference 10

those who are not familiar with the area may not know how to get there. It is noteworthy that such information was first organized and integrated on an open information infrastructure, namely Google map, and then sent out again in a user-friendly manner.

4-3 Robustness of Twitter and Skype

Social networks, such as Twitter and Skype, were robust during a disaster because they used Internet network. However, the use of Internet network alone cannot guarantee robustness at the time of disaster. Even if the Internet is connected, a rapid and large increase in the amount of information and processing bring down servers and routers. In other words, the same phenomenon as congestion with telephone service would happen.

Robustness at the time of disaster requires scalability so that the ability can be quickly altered corresponding to a rapid increase or decrease in the amount of information and data processing. Since land-line and mobile phones did not have enough scalability, communication through them had to be restricted. Twitter ensures this scalability by using the external cloud service and Skype by the technique called super-node.

Although Twitter uses self-developed software, many of its functions depend on the external cloud services. For example, it uses Amazon S3 for online storage service, and Amazon CloudFront for contents distribution service. Amazon CloudFront has distribution servers in 8 regions in the United States, 4 regions in Europe, and 2 regions (Tokyo and Hong Kong) in Asia. When making an access to a file in Amazon S3, the user will be led to the closest distribution server.[12] In other words, a tweet in Japan is processed in Japan as a rule.

However, when the amount of information increases rapidly due to a disaster or other reasons, the storage volume and processing ability increase automatically or an overseas server will be used. In this way, Twitter does not experience congestion even at the time of disaster and makes connection without fail. The most distinctive feature of cloud service is its scalability to increase or decrease its capability swiftly whenever it is needed[13,14]; Twitter, utilizing cloud service, naturally has the scalability as well.

On the other hand, Skype ensures its scalability by the technique called super-node. Skype chooses one personal computer that has higher transmission rate and higher processing ability out of every 1,000 computers accessing to Skype. The chosen computers are forced to take care of a part of the entire process of Skype (See Fig. 6). In other words, the CPU and volatile memory of the chosen computer not only perform the necessary processing for its own free video call, but also bear the functions necessary for Skype as a whole, such as list management and helping other users to call or connect to Skype. In this way, a grid of super-nodes is created for distributed processing as needed through users' personal computers. This ensures scalability, because if the number of accessing computers becomes ten times, the number of super-node computers for distributed processing also becomes ten times or more.

Skype was available as usual at the time of the disaster because its scalability was ensured in this way. It also has a charged service to make a land or cell phone call, which will be usable without
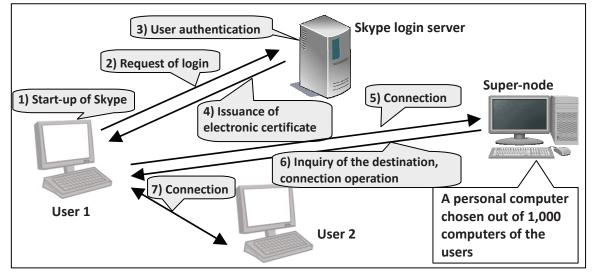

Figure 6: Connection process of Skype

Source: Prepared by the STFC based on Reference 15

congestion because it uses Internet network instead of telephone network. On May 10, 2011, as of the writing this paper, Microsoft Corporation announced the takeover of Skype Global (Luxemburg). In the future, Skype may be utilized for Xbox (a game console) teleconference system, and may be possibly useful for emergency TV conferences at the time of disaster.

4-4 Mirror sites and cloud services

In the metropolitan area, the websites of Tokyo Electric Power Company and railway companies were frequently disconnected because too many people were trying to access them to get information on planned electrical outages and train schedules. Also, in the disaster-affected areas, the websites of the municipal governments were down for a long time.

There are means to ensure scalability for websites as well. One of them is to use a mirror site. A mirror site has the exactly same format and the same contents as those of the original website, and when the original website gets updated, the mirror site is automatically updated. In order to avoid too much concentration of access, many academic paper repositories, software development and distribution sites, and various download sites have several mirror sites in different countries. In some systems, users choose a mirror site to access by themselves, and in other systems, users are automatically led to an available mirror site.

Even when the original website became unavailable due to the server down caused by a disaster, the mirror website will work as usual and ensures the robustness. Also, an alternative machine is often needed when a server experiences breakdown; in such a case, the website cannot be restored to its normal state until distribution system is recovered, if it does not have a mirror site.

Websites of municipalities and public organizations are not usually made in such a way to be able to handle heavy traffic. In fact, some websites of the disaster-stricken prefectures and municipalities caused system failures due to concentration of accesses even if the servers were not damaged. After the disaster, cloud providers voluntarily supported the affected municipalities and public organizations by constructing their mirror sites. For example, Internet Initiative Japan Inc. set up about 180 mirror websites of all the affected municipalities,[16] and SAKURA Internet Inc. set up 31 mirror websites of public organizations related to disaster prevention.[17] However, mirror sites of a few

municipalities with severer damages had yet to be established as of April 13; they were Ofunato-shi, Otsuchi-cho, Okuma-machi. Nonetheless, Otuschi-cho and Okuma-machi provided information through a temporary website.[16] Cloud providers offered various IT solutions taking advantage of the swift action of Cloud service, in addition to setting up mirror sites.

Mirror sites are highly effective in terms of risk diversification. It is fair to say that a permanently-installed mirror site is critical and essential for the websites of national and municipal governments and websites related to lifelines. Since cloud service incorporates the concept of a mirror site and its actual functions, it is also recommended to use external cloud service.

5 | New Partnership among Information Media

5-1 Television programs on the Internet

Radio and TV broadcasts are excellent means to quickly announce the warnings of earthquake and tsunami. Immediately after the earthquake, they informed the scales of the earthquake at various locations, too. In particular, TV broadcasts, which continuously sent shocking images from the devastated areas, played an important role as a mass medium. However, not everyone was able to watch TV at that time. Some people may have been able to watch TV through one-segment broadcasting system built in their mobile phones, but many people working in their office could not watch TV broadcast.

In this disaster, it was the mirror broadcasting (http://ustream.tv/channel/jishinsokuhou, etc.) posted by general users that responded well to the needs of those who could not watch TV. Normally, this is an act that may violate copyright laws in Japan. However, this was treated as an exception due to the emergency. At 5:40 pm on March 11, NHK's official twitter @NHK_PR tweeted as a personal opinion, "There are many regions where people cannot watch TV. Since this is a matter of life or death, if there are any means to transmit information, we would like people to utilize them."[18]

In this way, TV stations immediately realized the importance of the Internet, and set up official channels on Ustream or Niconico Live, to stream or simulcast their news programs onto the Internet. For example, NHK ran the video streaming of its news on http://

www.ustream.tv/channel/nhk-gtv and http://live.nicovideo.jp/watch/lv43018790, TBS on http://www.ustream.tv/channel/tbstv, and Fuji Television on http://live.nicovideo.jp/watch/lv43019860. These news programs were accessible not only within Japan but also from abroad.

5-2 A new trial of the Internet

TV and other mass media played a major role as news media, by sending images from the devastated areas. However, they also revealed the weakness of mass media; they could not adequately transmit the important and necessary information for disaster victims, such as information on safety of people. It would have been possible to provide sufficient information if the number of victims had been 50 or 100. However, when many evacuation shelters were set up over extensive areas and the number of victims reached tens of thousands, mass media became completely helpless for victims and all they could do was provide live broadcasts from some of the evacuation centers. Such TV programs showed people who were wandering around from one shelter to another, looking for the information on their family members and trying to find their names on the list tacked on the wall of each shelter.

The Internet and volunteers throughout the country compensated for the weakness of mass media. First, volunteers in the affected areas and evacuees themselves took pictures of the name lists displayed in shelters and posted them on the Web. Google launched a photo sharing service for the name list of evacuees using Picasa on its website. On March 14, Google called for volunteers and evacuees to post more pictures. In particular, they were asked to add the location data if GPS function was available, because this would enable links with map. Thus more than 4,600 volunteers uploaded over 9,000 photos.[19]

In this way, people could look at the name lists and messages of evacuees without going to the evacuation shelters. As a result, there were many cases where relatives and friends in remote locations were able to make contact with evacuees.

However, photo information was not very useful. It was quite difficult to search for the name of specific individual unless the photo images are converted into textual information. Therefore, Google looked for volunteers who would read out the uploaded photos and convert them into the name list in text format.[19] More than 3,300 volunteers throughout the country participated and converted nearly 90% of the pictures into text format in a short period of time, which was then compiled into a list. Thus, "Person Finder", a safety confirmation tool by searching for individual name, had been established.

"Person Finder" has the entry screen shown in Figure 7 and allows the users to input more information on people's whereabouts. By adding the name lists of evacuees offered by news media such as NHK, the number of retrievable data increased largely to 622,300. The registered data have decreased to about 14,000 as of June 10, 2011, because the data that
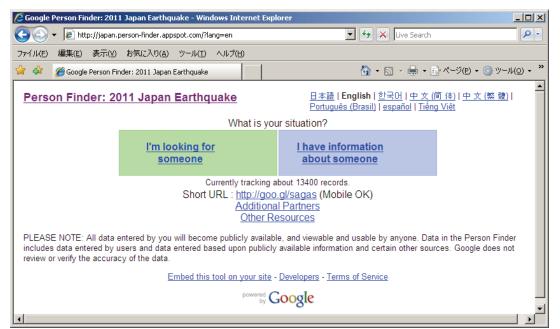

Figure 7: Entry screen of "Person Finder"

Source: Reference 20

became unnecessary was deleted.

This is not the first time Google's Person Finder was used. It started with "Katrina people Finder Project" that coordinated different formats of missing person registries on several websites which were started up after the hurricane "Katrina" hit the United States in 2005. After that, the Person Finder was also used at the time of the Haiti Earthquake in 2010. It may be said that the Person Finder was launched quickly this time thanks to these previous experiences.

If fragmented information is offered discretely, it is not useful for a recipient of the message. It is extremely important to accumulate and organize information at first, and then to quickly transmit it in a user-friendly manner, as Person Finder and the real-time map for stranded commuters did. Another important point is to have an open system that can call in many volunteers all over the country. Furthermore, it is important for each volunteer to be able to work in the system environment he or she uses routinely, without the need to use a particular machine or go to a particular place.

6 | Conclusion

At the Great East Japan Earthquake, the Internet exhibited more robustness than expected, while telephone services and texting on mobile phones were disrupted. This is because the Internet itself possesses robustness such that the Internet traffic can bypass damaged places automatically to make connection. The optical undersea cables were damaged in various spots, but the Internet stayed connected to the world through the southbound cable as an alternate route. As far as the enhancement of robustness in a disaster is concerned, these facts show that it is far more important to prepare the way to compensate possible damages or breakdowns than to try to create something completely unbreakable or absolutely safe.

Another remarkable new movement was the use of Twitter and other social networks as a means of information distribution. Simple connectivity is not enough to ensure robustness at the time of disaster. Another important thing for robustness is scalability to address a rapid increase or decrease in the volume of information and processing. Telephone service experienced congestion and became unusable at this disaster due to the insufficient scalability. On the other hand, Twitter ensured scalability by using the external

cloud service and Skype by super-node. As a result, both of them could keep working as usual without system failure even when the volume of information increased dramatically. There is also a means called mirror site to ensure scalability of website.

TV broadcasts played an important role as a mass medium by announcing the warnings of earthquake and tsunami quickly, and by showing the devastating videos of the disaster. However, they also revealed their weakness such that they could not provide sufficient information necessary for disaster victims when the number of victims became enormous and the disaster areas were widespread.

The Internet and social networks compensated the weakness of mass media. They were used as media not only because they had robustness and scalability; it was because, along with their swiftness, they were familiar and open to the public. These features allowed people to freely and adequately provide the information to those who needed to receive it in a user-friendly manner. Typical examples of such activities were "Real-time map of shelters for stranded commuters" and "Person Finder". Because such open information applications were offered, many information volunteers could come together in order to collect and organize information rapidly, and to send out it in a user-friendly manner

These movements can be regarded as examples of open innovation that happened voluntarily in an extremely short time. However, there were also cases where aged evacuees could not receive enough information and necessary supplies. In this respect, the role of information volunteers who transmit detailed information to and from information shortfall will increase more and more in the future.

From now on, science and technology policy is going to emphasize that "the national and local governments . . . need to properly provide information on a disaster and on evacuation to the local residents, and they should advance efforts that contribute to this."[21] I will be happy if this report can serve as a useful reference.

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Profile

Tsuneo ICHIGUCHI
Affiliated Fellow
Information and Communications Research Unit
Science and Technology Foresight Center
http://www.nistep.go.jp/index-j.html
Ph.D. in Physics. Specialized in physics of semiconductors, superconductors, and magnetism. Engaged in research, primarily on measurement using sub-millimeter waves and microwaves, at an American university and a Japanese electric appliance company. Currently engaged in research on the forecast and trends of science and technology at the STFC.

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5

Recent Trends in Neutron Beam Assisted Material Analysis Technology

Hidenori GAMO
Nanotechnology and materials unit

Wakana TAMAKI
Nanotechnology and materials unit

1 | Introduction

We have witnessed, in recent years, substantial and rapid growth in technologies for high-precision generation and control of particle beams (electron, ion, and neutron) and radiation (X-ray), accompanied by ramifications thereof in such areas as high-precision analysis and material processing, taking full advantage of the technologies. These developments have worked to now collectively establish a research domain called "quantum beam technology." Utilization of quantum beams enables us to analyze the atomic-level structure of metallic-, ceramic- and biological materials. The quantum beam technologies are expected to lay the foundation for the future development efforts of new energy materials and novel pharmaceuticals.[1]

Among the classes of quantum beams, neutron beams have a peculiar characteristic in that they are electrically neutral – entirely void of electric charge – and interact solely with atomic nuclei without interference from the surrounding electrons. Application of the neutron beam in material analysis enables detection and analysis of light elements that are mostly beyond the reach of traditional X-ray and electron beam methods.

This report presents the mainstream trends in this research area, mainly from the viewpoint of material analysis, including an introduction to the characteristics of neutron beams and some cases of practical material analysis. It also includes a discussion on the future perspective.

2 | Characteristics of the neutron used for material analysis, and method for its creation

2-1 Characteristics and properties of neutron

The neutron was first discovered by J. Chadwick in 1932, and later, W. Heisenberg theoretically predicted that the atomic nucleus consisted of protons and neutrons.[2] The neutron has a mass comparable with that of the proton (1.675×10^{-27} kg) and is characterized by its electrical neutrality: it has neither positive nor negative charge. The neutron cannot occur in nature by itself and only escapes as a single particle when an atomic nucleus decays. It has an average lifetime of around 15 minutes, and undergoes spontaneous decay resulting in such elementary particles as protons, electrons, and anti-electron neutrinos. Because it is entirely free of electrical charge, the neutron interacts only with atomic nuclei when it travels inside a material, without interference from electrons. The neutron, after its creation, can travel at an average distance of around 220m before it collides with other atomic nuclei (mean free path). The neutron has a spin – an intrinsic characteristic of an elementary particle that exhibits magnet-like properties – therefore, it behaves like a tiny magnet (Figure 1).

2-2 Characteristics of material analysis by means of a neutron beam

The neutron beam represents a collimated bundle of neutrons traveling in one direction, and belongs to the class of particle beams such as the electron beam and ion beam. It also belongs to the class of radiation such as α-rays (helium nucleus), β-rays (electron) and γ-rays (electromagnetic radiation): discovered by A. Becquerel.[2]

At present, X-rays (electromagnetic wave) and

electron beams (charged particle) are widely used as tools for material analysis, taking advantage of their properties, capable of exerting electric force through electric fields and electrical charge. Namely, they interact with the electric charge (i.e. electrons) distributed inside the material. The interaction is weak in light elements, such as hydrogen, because of the small number of electrons: the signal available for analysis becomes faint or totally imperceptible.

The charge-free neutron beam, on the other hand, does not interact with the charged electrons when a material is irradiated with one. As a result, interactions between atomic nuclei become more outstanding in comparison with that with electrons, making it a helpful tool to elucidate material structures that lay beyond the reach of X-rays and electron beams. A variety of methods and devices have been developed to utilize the neutron beam for material analysis, and these are broadly classified into two categories:

neutron diffraction and transmission (Figure 2).

Table 1 summarizes the characteristics of neutron-beam-based material analysis in comparison with those of the X-ray method. As interference of waves (Bragg diffraction[5]) is used in structural analysis, the wavelength range employed corresponds to the interatomic distances in a crystal (i.e. 0.1-0.2 nm). The wavelength of an X-ray, a type of electromagnetic wave, is determined by its energy, and neutron wavelength can be adjusted by controlling its traveling velocity. As the typical neutron velocity in thermal equilibrium (2,200 m/sec) approximately corresponds to the energy level of atomic vibration (25.3 meV), the neutron can also be used to obtain information regarding the vibrating atoms.

2-3 Creation of neutron beam

To perform a highly sensitive measurement with high resolving power in a short period of time, a
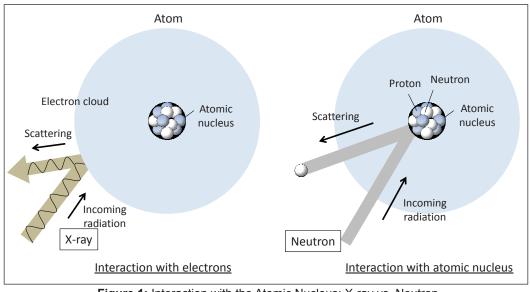

Figure 1: Interaction with the Atomic Nucleus: X-ray vs. Neutron
Prepared by the STFC based on reference[3]

Figure 2: Material Analysis Using Neutron Scattering and Transmission
Prepared by the STFC based on reference[4]

Table 1: Comparison of X-ray and Neutron

Source	X-ray	Neutron beam
Physical state	Electromagnetic wave (photon)	Neutral particle (material wave)
Wavelength *	0.1-0.2 nm	0.1-0.2 nm
Energy *	6-12 keV	10-30 meV
Scattering application (e.g. crystal structure analysis)	Interaction with electrons (suited for electron-rich elements)	Interaction with atomic nuclei (not affected by the number of electrons) (capable of analyzing spin and magnetism)
Transmission application (e.g. nondestructive analysis)	Projects electron-rich materials (advantageous for analysis of metals and ceramics)	Projects materials with fewer electrons (advantageous for analysis of light elements and organic substances)

* Energy and wavelength range commonly used for crystal structure analysis

Prepared by the STFC

Figure 3: Neutron Creation Using an Accelerator: Nuclear Breakdown

Prepared by the STFC based on reference[4]

Figure 4: Energy Selection Method for Pulsed Neutrons

Prepared by the STFC based on reference[6]

neutron beam with high intensity (high neutron density) and uniform energy (narrow energy width) is required. As a neutron source, nuclear fission or breakdown can be used for producing them.

Nuclear fission taking place inside a nuclear reactor can provide neutrons. Low energy thermal neutrons – those that have attained equilibrium with the thermal agitation of surrounding molecules through multiple collisions with nuclei – are used for material analysis. Thermal neutrons, however, have a somewhat blurred range of energy, making it difficult for them to be used in a high-resolution material analysis. Another method of neutron creation makes use of nuclear breakdown: a proton (hydrogen nucleus) accelerated to nearly the speed of light by the accelerator is slammed into target atoms (e.g. Hg atom), breaking down the nucleus and emitting secondary particles. This process creates elementary particles such as muons and neutrinos, as well as neutrons (Figure 3). The neutrons thus created are characterized by a very high level of energy, and are moderated by passing them through hydrogen or light hydrogen to an energy level comparable with thermal neutrons, or several tens of meV. This method is also characterized by pulse bombardment: pulsed protons are slammed into the target atoms creating a train of narrow-width pulsed neutrons, enabling energy level selection by measuring the time-of-flight – from the time of neutron creation until its arrival at the detector. This method allows obtaining a neutron beam with a very narrow energy width (Figure 4). With the increasing number of facilities that provide access to a high-quality pulsed neutron beam, and with the availability of ever increasing beam intensity, this technique is receiving attention in recent years in view of material analysis.

2-4 Large-scale accelerator facilities for neutron beam creation

In recent years, large-scale neutron beam facilities are being constructed in succession in major research countries around the world. The facilities usually include accelerators that produce high-quality, high-intensity beams of pulsed neutrons. At present, high-power (0.1-1 MW) accelerator facilities are in operation in three countries: ISIS[7] at Rutherford-Appleton Laboratory (UK), SNS[8] at Oak Ridge National Laboratory (USA), and J-PARC[9,10] (Japan). Other ongoing undertakings include the ESS (European Spallation Source) project (EU)[11] and CSNS (China Spallation Neutron Source) project (China).[12]

J-PARC, located in Tokai village (Ibaraki Pref.), is a facility jointly owned by the Japan Atomic Energy Agency (JAEA) and High Energy Accelerator Research Organization (KEK), and provides, as of 2010, one of the world's highest levels of high-intensity (in terms of neutron number) and high-quality neutron beams. J-PARC has 23 beam lines to be used for research in material and life science: each of these beam lines provides services for research mainly related to the evaluation method development for a variety of advanced devices in such domains as: functional materials, structural materials, high-efficiency batteries, fuel cells, catalysts, and engines.

Among them, the following two beam lines are owned by Ibaraki prefecture and are made available for supporting industrial use by private sector enterprises: BL-03 (for structural analysis of life substances: iBIX), BL-20 (for crystal structure analysis of materials: iMATERIA).

3 | Neutron Beam Applications in Material Analysis Technology

The neutron beam as used in material analysis technology has a range of promising applications in a variety of research areas as shown in Figure 5. This report introduces some of the representative neutron beam applications in material analysis centered in the following two areas: crystal structure analysis using neutron beam diffraction (scattering) and neutron radiography (transmission).

3-1 Crystal structure analysis using neutron beam scattering

As described in Chapter 2-2, the neutron exhibits a wave-like nature, enabling its use as a tool for crystal structure analysis just as X-ray is used for that purpose – the principle of Bragg scattering (diffraction).[5] The neutron diffraction method is especially useful for analyzing crystals that contain light elements such as hydrogen, lithium, oxygen, and nitrogen. Neutron beam diffraction is one of the classical methods, and it found new applications as a tool for material development, triggered by the high-temperature superconductivity fad around 1990. In the material development effort for use in high-temperature superconductivity, the method was

Figure 5: Areas of Material Analysis Where the Neutron Beam Can Play an Important Role

Prepared by the STFC

Figure 6: Schematic Representation of Structural Analysis Using Neutron Beam

Source: reference[13]

used to determine locations of oxygen (or oxygen vacancy) and light elements (e.g. boron and carbon) contained in a rare-earth element matrix, as well as for determining magnetic structure. More recently, research is underway to expand the applicability of neutron diffraction in such areas as: behavior observation of light elements – lithium and hydrogen – in lithium-ion battery and fuel cell matrixes, and structure determination of hydrate-containing proteins and DNA.

Figure 6 schematically represents the approaches taken by three study examples for the structural analysis of $Ba_2[Al_4Si_{12}O_{32}] \cdot 12H_2O$ (hydrate).[13] Note

that, in this figure, the geometrical cross-sections of the spheres are sized so that they are proportional to their scattering cross-section.

1) Neutron beam vs. X-ray: Characteristics in structural analysis

While X-ray analysis generally provides clear signals from electron-rich elements, i.e. Ba, it provides only faint signals from elements with fewer electrons, i.e. hydrogen (H) and oxygen (O). In contrast, analysis using a neutron beam produces clear images of H and O.

2) Analysis using isotopic contrast

The strength of neutron-nebulous interaction

depends on the structure of the atomic nucleus. Substitution of hydrogen (H) with deuterium (D) will enhance the signal from the hydrogen position. Therefore, subtraction of the original image from the deuterated one will leave only the information related to the substituted hydrogen atoms. This technique is called isotopic contrast, and can be an effective approach for other atomic species other than hydrogen.

3) Analysis using spin contrast

Because the neutron has a spin, the interaction with the atomic nucleus spin can be used to enhance the image contrast for better analysis. An image with highly enhanced contrast can be obtained by controlling the neutron spin and nucleus spin separately, i.e. a comparison of a parallel spin image and an anti-parallel image.

3-1-1 Analysis of lithium-ion battery electrode materials

The development of lithium-ion batteries – the major rechargeable battery for portable devices and next generation automobiles - is now energetically underway. The behavior of lithium ions between the anode and cathode has a significant influence on battery performance. Figure 7 shows the results of structural analysis of $LiMn_2O_4$ (cathode material). While the results obtained using X-rays include blurred images of oxygen (O), that obtained using the neutron beam presents clear oxygen images and even the lithium images are visible. This is a promising achievement for the future crystal structure elucidation of battery electrodes.
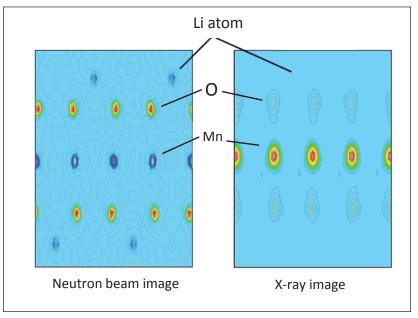

Figure 7: Structural Analysis of Lithium Ion Battery Cathode Material

Source: reference[14]

Figure 8: Structural Analysis of Protein

Source: reference[15]

3-1-2 Structural analysis of biological materials

Biological materials, such as proteins and DNA, are surrounded by a host of hydrates. Structural analysis using the neutron beam can reveal the positions of water molecules – hydrogen and oxygen. These light elements are almost invisible to X-ray (Figure 8). At present, preparation of large crystals presents a huge challenge for the technique to be useful in the analysis of organic materials. Still, the neutron beam has the potential to become a practical method for pharmaceutical and cosmetic product development in the future.

3-2 Interior observation of materials: transmission of neutron

X-rays are easily absorbed by many-electron elements such as metals. The neutron beam shows good transmittance through metallic elements, and is absorbed relatively easily by light elements such as hydrogen, water, oxygen, and nitrogen (Figure 9). Neutron radiography is a measurement method taking advantage of these characteristics, and allows us to observe the distribution of water, fuel, and organic materials inside metallic/ceramic structural objects (Figure 10, 11).[16] This analysis technique has been applied in nondestructive inspection – for example, soot deposition distribution inside the exhaust treatment catalyst of diesel engine automobiles.[17] In addition, research is underway to use this technique for the observation of water inside fuel cells.[18] Device research is also underway: small and movable neutron sources are being developed that can be used in on-site inspection of degraded/damaged components in architectural structures (e.g. bridges).[19]

Figure 9: Absorption Coefficient of X-ray and Neutron Beam: Dependence on Atomic Number

Source: Reference[16]

Neutron beam image   X-ray image

Figure 10: Transmission Image of an Engine

Source: Reference[16]

Figure 11: Infiltration of Water Through Concrete Cracks (Time Change)

Source: Reference[16]

Table 2: Typical Cases of Neutron Beam Application Study

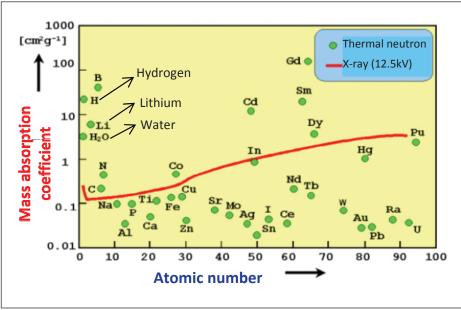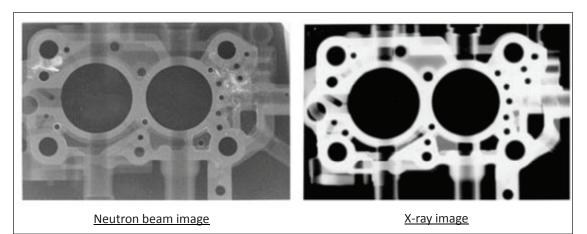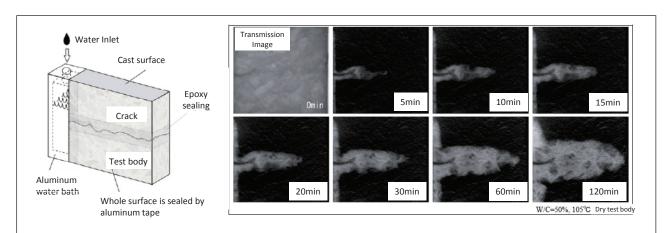| Material	Method	Cases of analysis
Inorganic functional material	Powder neutron beam diffraction	Structural analysis of: nitride fluorescent substance, lithium-ion battery cathode material, lithium battery ionic conductive body, oxide/magnetic material, hydrogen trapping mechanism of hydrogen storage material, ceramic material.
Bio-polymer material	Neutron beam diffraction	Structural analysis of: glycoenzyme in plant tissues, proteins, organic compound crystals.
Magnetic/polymer material	Neutron small angle scattering	Magnetic structure analysis of nanomagnetic particles and crystals, magnetic domain analysis of perpendicularly magnetized films, quantitation of rust growth in anticorrosion steel, analysis of molecular chain distribution in rubber bulk matrix, structural analysis of fillers in rubber material, particle size analysis of crosslinked rubber.
Industrial material	Neutron beam diffraction (residual stress measurement)	Internal strain measurement of welded bodies, strain and stress distribution measurement of carburized carbon steel, stress measurement inside reinforced concrete blocks.
	Neutron radiography	Flow property evaluation of a powder used as the developer for electrophotographic system, evaluation of bubbles in inks, evaluation of subcutaneous defects of steel, visualization of flow inside welded bodies and hydraulic valves, Inspection of liquid fuelled rocket combustors, deformation visualization of magnetic valve seals.
Thin-film material	Neutron reflectance measurement	Surface/interface structural analysis of: optical memory, magnetic bodies, dielectrics, condensers, multi-layer reflective coating, steel material, battery electrodes, and polymer thin-film
Semiconductor	Neutron doping	Nuclear transformation from ^{30}Si (approx 3% of Si) to ^{31}P
	Prompt γ-ray analysis, activation analysis*	Impurity evaluation of semiconductors
Agricultural crops	Neutron radiography	Distribution and behavior of water in plants and fruits, perspective visualization of soil and plant roots.
	Prompt γ-ray analysis, activation analysis*	Heavy metal detection in agricultural crops, Hg detection in soil, production region identification of beef.
Cultural assets0	Neutron radiography	Nondestructive analysis of pearls embedded inside a bronze mirror.
Others (nondestructive inspection)	Neutron radiography	Water content analysis of rocks, properties analysis of scallop shells as asphalt material.
	Prompt γ-ray analysis, activation analysis *	Production region identification of stone materials, heavy metal analysis of scallops, hazardous substance analysis of construction waste materials, component analysis of cosmetic products, chloride analysis of concrete, nitride analysis of explosives and waste chemical weapons, elemental analysis of optical components.

* Prompt γ-ray analysis: a method of elemental (isotope) analysis based on the measurement of γ-ray spectrum emitted when a neutron is absorbed by an atomic nucleus. Activation analysis: a method of elemental analysis based on the detection of disintegration γ-ray spectrum emitted from radioactive nuclides, which are created when a neutron is absorbed by an atomic nucleus.

Prepared by the STFC

3-3 Cases of neutron beam application in material research

Table 2 summarizes the cases of material research conducted using the JAEA's thermal neutron source (JRR-3). These studies are listed in the case report[20] of the "Transfer Promotion Program of Neutron Utilization Technology" – a program conducted as a part of a project sponsored by MEXT starting in 2007.

4 | The Challenges We Are Facing, and the Future Prospects

The introduction of neutron beam technology has enabled us to conduct detailed analysis of battery materials and biological materials. As affairs now stand, researchers still have such challenges as the long analysis time that renders dynamic observation difficult, and the need for larger crystal samples. In J-PARC, output power upgrading of neutron sources ($\frown$ 1 MW) and proliferation of various experiment devices are currently underway. These efforts are expected to help boost the experimental conditions in the future: more accurate and speedy material analysis using a smaller amount of samples. Enhanced output power of the neutron source will enable, for example, the behavioral observation of hydrogen atoms inside the electrolyte membrane (fuel cell development), as well as the rapid and dynamic conformation analysis of proteins that contain hydrogen and hydrates. The sample sizes required may be reduced to a level comparable to those for X-ray analysis. These developments will enable, for example, magnetic structure analysis of novel high-temperature superconductivity materials and low-dimensional organic magnetic materials. Other possibilities include in-process, time-split measurement of steel materials.

Analysis of materials that contain light elements requires a high-intensity neutron source, resulting in the need for large-scale common facilities such as J-PARC. For a better utilization of these common facilities, establishment of a user-friendlier environment is highly desirable both in terms of technological and administrative aspects, accompanied by enhanced collaboration among industry, academia and government. Another noteworthy trend is the development of small-sized portable/moveable neutron sources: these are used, for example, in on-site inspection of defective components in architectural structures made of concrete and ferrous materials, as well as in nondestructive inspection of industrial products and security screening of baggage, whereby the experimental results obtained through the use of large-scale neutron sources will be of help. The global trend in the material analysis technologies using neutron beams deserves continuous monitoring into the future.

The facilities in J-PARC, located in Tokai village, Ibaraki Prefecture, suffered severe damage due to the 2011 Tohoku Earthquake, and research activities there are halted as of the time of this writing. As a closing remark, the authors would like to extend their deepest sympathies for those working in the facilities, and wish for the earliest possible recovery and revitalization.

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Profile

Hidenori GAMO
Nanotechnology and materials unit
Fellow: Science & Technology Forecast Center
http://www.nistep.go.jp/index-j.html
Dr. Gamo acted as a researcher in a private sector enterprise research laboratory, and engaged in the areas of carbon nanotubes, micro-machined electron source and display (application of semiconductor films), and application of illumination devices. During these periods, he did collaborative research at AIST (Advance Industrial Science and Technology), NIMS (National Institute of Material Science) and universities as a visiting fellow. He joined STFC in April 2010. He is a member of the No.158 committee (vacuum nanoelectronics) of the Japan Society for the Promotion of Science, and a science fellow of the Surface Finishing Society of Japan. PhD in engineering (Kyoto University).

Wakana TAMAKI
Nanotechnology and materials unit
Researcher : Science & Technology Forecast Center
http://www.nistep.go.jp/index-j.html
She was born in Okinawa. She is a master in science and joined STFC after research in a private sector company and a university. She was strongly interested in the mismanagement problem of used automobiles in her teens, and has been engaged from her university years in statistical survey of metallic resource recycling. She was strongly inspired by some of the materials she encountered during the survey activities. Her current interest is to convey the same "inspiration and excitement" of material research to others.

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6

Initial Responses to the Great East Japan Earthquake by the Academic Community in the United States

Satoru ENDO
Affiliated Fellow

1 | Introduction

In response to the magnitude 9 earthquake and tsunami that struck east Japan on March 11, 2011 and the subsequent nuclear power plant accidents resulting from the earthquake and tsunami, academic communities both in Japan and abroad responded in various ways. This article describes the initial actions the academic community in the United States took, in particular from the researchers' point of view, in response to the disaster and accidents that took place in another country (Japan). Specifically, based on information on websites and other media, this article looks at those activities that occurred in the first two months or so following the earthquake and accidents.

Incidentally, the United States Armed Forces, the Federal Emergency Management Agency (FEMA), the Nuclear Regulatory Commission (NRC), Department of Energy (DOE), and other government organizations have been working with the Japanese government to respond to the earthquake, the tsunami, and the accidents at the Fukushima Daiichi nuclear power plant. There may have been cases where academic organizations and individual researchers were involved directly or indirectly in these governmental activities, but this article does not aim to examine such activities.

2 | What This Article Covers

2-1 Academic Community in the United States and the Outline of Their Responses

This article targets the academic community, particularly organizations referred to as academic societies and associations. These academic organizations in the United States are not acknowledged by the government, unlike, for example, the Science Council of Japan's cooperating academic research organizations. This article selected organizations whose presidents are the member of the Council of Scientific Society Presidents as well as organizations whose presidents are not included in the council but which covers the fields of earthquakes, tsunamis, nuclear energy, radiology, and other fields related to the recent earthquake and nuclear power plant accidents and which have participating researchers from universities and public research institutions.

Some 62 organizations make up of the Council of Scientific Society Presidents, and among them, 20 organizations (about one third) published information about the Great East Japan Earthquake and the accidents at the Fukushima Daiichi nuclear power plant. This figure is only limited to certain organizations, and so, it may not reflect trends for all academic organizations in the United States. However, one can say that a certain number of organizations clearly expressed their interests. More specifically, six organizations expressed their concerns and support for the Japanese people and the academic community in Japan; 15 organizations provided information to their members; and three organizations provided information to the public. In addition, the American Nuclear Society made proposals to policy makers, and the Health Physics Society announced that it would hold a special session at an academic conference. Some organizations published information more than once, and so the total number of cases where information was published is more than 20 (the number of the organizations which published information).

In the United States, some academic organizations have purposes and missions that are not directly related to academic research even though their core value is the advancement of academic research. For example, the Union of Concerned Scientists is one such organization and aims to build an

environmentally healthy and safe world. This article covers organizations that are not normally considered academic organizations by the Japanese standard if researchers participate in the organizations. Incidentally, many universities (research institutes) and non-profit research institutions actively provided information on the earthquake and the nuclear power plant accidents. The MIT NSE Nuclear Information Hub and several seismology and earthquake engineering centers that were established with the support of the National Science Foundation (NSF) were among them. However, this article does not aim to introduce actual research and so does not include these activities.

2-2 Methods of Identifying Information

The academic community in the United States responded to the earthquake and nuclear power plant accidents in different ways. This article categorized their activities into four groups: 1) the expressions of concerns and support for the Japanese people and Japanese researchers, 2) provision of information to researchers and the general public, 3) advice and assistance for national policy making, and 4) the development of academic research related to the earthquake and nuclear power plant accidents.

The main method of identifying information was to access information on each organization's website. During the process, relevant Web pages were narrowed down by using search engines on each website and Google's site search to search for keywords such as "Japan," "nuclear," "earthquake," "tsunami," and "Fukushima." This article does not cover Web pages that are restricted to members only or have other types of access restriction, with the exception of some academic articles. Some relevant Web pages might not have been identified if academic organizations had set up the pages on different sites and had not included links on the original websites. This survey was conducted roughly between the one- and two-month anniversaries of the earthquake and the accidents. Some information might have been posted temporarily right after the earthquake and then eliminated, and some information might be revised or eliminated by the time this review is published.

Due to the methods used in this article, statistical reliability may not be high. However, the purpose of this article is to understand the action taken by the academic community in the United States right after the earthquake, and so I believe that a sufficient amount of information was acquired.

3 Expressions of Concerns and Support for the Japanese People and Researchers

Firstly, many academic organizations in the United States expressed concern for the Japanese people and researchers who are members of their related academic organizations in Japan, expressed their condolences for the victims, and expressed their determination to give support by way of, for example, fundraising. The forms and content varied, but they can be roughly categorized into: 1) expressions of concern and condolence to the victims, 2) expressions of concern for researchers who are members of related academic organizations in Japan, 3) fundraising (to be conducted by each academic organization), and 4) fundraising through the Red Cross and other organizations.

One could find, on many organizations' websites, these expressions of condolence for the victims and concern for researchers who are members of their related academic organizations. For example, among the organizations in the Council of Scientific Society Presidents, condolences and concern were expressed by the American Chemical Society, the American Crystallographic Association, Inc., the American Nuclear Society, the American Psychological Association, the Society for Neuroscience, and SPIE (the international society for optics and photonics); the president of the IEEE (Institute of Electrical and Electronics Engineers) posted a message for the members in Japan on its website; and seven out of the 38 member societies expressed their concern on their websites. Additionally, some organizations asked their American members to donate to the Red Cross and other organizations in their statements to express concern or to report on the conditions. The American Nuclear Society set up its own Japan Relief Fund and began accepting donations.

4 Provision of Information to Researchers and the American Public

Many academic organizations have provided information on their websites. The American

Association for the Advancement of Science (AAAS) published news articles about the earthquake and nuclear power plant accidents on its journal Science (both printed and electronic versions) for the subscribers (AAAS members). Some organizations provided information on their websites by publishing related articles in their periodic newsletters or creating special pages on the earthquake and the accidents. The content also varied. Some organizations announced their official opinions and others let their members write their opinions freely in a blog style.

In addition, some academic organizations reprinted information from the Japanese, the American, and other countries' media as well as from related Japanese and American public organizations and electric power companies.

The information was mainly targeted at the members and experts. However, some organizations provided information to the general public, who do not have specialized knowledge. The following sections separately describe two types of information: information provided to the public with an aim to better educate them and information provided to researchers.

4-1 Provision of Information to Researchers
4-1-1 Science

The Great East Japan Earthquake and the accidents at the Fukushima Daiichi nuclear power plant were significant occurrences also in scientific and technological points of view. Both Science (published by the AAAS) and Nature (a commercial journal published in the United Kingdom) published articles on the disasters. Table 1 illustrates the titles and outlines of published articles (including short news notes) in Science between the occurrence of the earthquake and the May 20 edition.

Table 1 shows articles from the printed version of Science. Science Express (publication ahead of print) also published and updated academic reports on the earthquake. ScienceInsider (online news and analysis) also updated information in a section titled "Japan Earthquake: The Aftermath."

4-1-2 IEEE Spectrum

The IEEE (Institute of Electrical and Electronics Engineers) featured articles titled "Japan's March 11th Earthquake and Nuclear Emergency" on its newsletter, Spectrum. Spectrum is a monthly newsletter in print

form, and its online edition provides more information using blogs and other tools. All relevant articles, including the blog entries about the earthquake and nuclear power plant accidents, are put together into the feature page, "Japan's March 11th Earthquake and Nuclear Emergency." The articles are categorized into "Most Recent," "Commentary," "Infrastructure," "Search and Rescue Robots," "Earthquake and Tsunami Warning Systems," "From the Archive," and "Time-line of official TEPCO and IAEA announcements."

The "Most Recent," a blog-style page, posted a total of 70 byline articles by May 24. Those who are associated with IEEE as well as contributing authors who have contracts with IEEE wrote most of the articles. The content varied widely: 39 reports based on information coming from related organizations and the media in Japan and elsewhere; 12 research analyses and explanations conducted by the IEEE on the accidents; 4 technological reports and analyses related to the earthquake and the nuclear power plant accidents (for example, on robots); 10 commentaries that include personal opinions and interpretations; four interview articles; and an article posted by a Japanese researcher. The contributing authors in Japan who had contracts with IEEE often posted articles based on information from related organizations, the Japanese media and elsewhere. They acquired information from a wide variety of organizations and individuals, including TEPCO, government organizations, companies, and university researchers. IEEE also published its own research analyses and explanations on the nuclear power plant accidents. As to the technological reports and analyses in relation to the earthquake and the nuclear power plant accidents, Spectrum has been reporting on the use of disaster-relief robots, the attempts by an Air Force drone to acquire images of the reactors, and the functions of disaster-relief robots. The IEEE reviewed the use and the functions of such robots but did not suggest any actual robot names. In contrast, the Association for Unmanned Vehicle Systems International (AUVSI) selected and sent robots to Japan. This example illustrates a stance of an industrial organization, which is different from academic organizations. Individual opinions and comments published under "Most Recent" sometimes included sharp criticisms as contributors' personal views. However, the blog platform made it possible to publish opinions that are

Table 1: Articles from *Science* (March 18 through May 20, 2011)

Article titles	Outline
March 18 edition	
Devastating Earthquake Defied Expectations (vol.331, pp1375-1376)	Explains the mechanism of the Great East Japan Earthquake and how it was beyond expectation.
Waves of Destruction (vol.331 p1376)	Reports on the tsunami and damage.
March 25 edition	
Devastation in Japan: Nuclear Power's Global Fallout (vol.331, pp1502–1503)	Illustrates a world map that provides the locations of nuclear power plants in relation to seismic hazard zones.
Radiation Risks Outlined by Bombs, Weapons Work, and Accidents (vol.331 pp1504–1505)	Reports on radiation exposures after the Hiroshima-Nagasaki atomic bombs, the accident on Three Mile Island, the accident in Chernobyl, etc.
Candidate Radiation Drugs Inch Forward (vol.331, p1505)	Explains the difficulty in developing effective drugs for radiation exposures. The photo in the article shows the reactor building of the Fukushima Daiichi nuclear power plant after the building had a hydrogen explosion. The end of the article suggests that the accidents could accelerate the development of radioprotectants.
Current Design Address Safety Problems in Fukushima Reactor (Vol. 331 p. 1506)	Explains designs and functions of the reactors.
Fukushima Cleanup Will Be Drawn Out and Costly (vol.331, p1507)	Reports on the disposal of radioactive material at the Fukushima Daiichi nuclear power plant.
Japan's Research Facilities Down But Not Out (vol.331, p1509)	Reports on the impact of the Great East Japan Earthquake on research facilities and research activities in Japan. Reports on university management (Tohoku University), the Japan Proton Accelerator Research Complex (J-PARC), High Energy Accelerator Research Organization (KEK), and Chikyu (a deep-sea drilling vessel).
April 1 edition	
When Science and the Media Mix (vol.332, p13)	Refers to the Great East Japan Earthquake and the accidents at the Fukushima Daiichi nuclear power plant at the beginning of the article and explains the importance of communication between scientists and the media.
Scientific Consensus on Great Quake Came Too Late (vol.332, p22–23)	Explains that knowledge about the Jogan earthquake in 869 C.E. did not influence risk assessment policies, and comments on risk assessments of earthquake-induced tsunamis in Japan and elsewhere.
Pool at Stricken Reactor #4 holds Answers to Key Safety Questions (vol.332, pp24–25)	Reports on the problematic spent fuel storage pool for reactor #4 at the Fukushima Daiichi nuclear power plant.
April 8 edition	
Nuclear Crisis Drags On (vol.332, p154)	Reports on the leakage of water contaminated with radioactive material.
April 15 edition	
Japan Widens Evacuation Zone (vol.332, p288)	Reports on the expansion of the evacuation zone and the government's announcement to raise its rating on the International Nuclear and Radiological Event Scale to seven.
By the Numbers: 37.9 (vol.332, p290)	A short news lines about the highest height of the tsunami examined by an investigating team.
Fukushima Radiation Creates Unique Test of Marine Life's Hardiness (vol.332, p292)	Presents a view that one should not overreact about eating fish in relation to radioactive material leaked from the Fukushima Daiichi nuclear power plant into the ocean. Reports on interests in biological research for the impact of radioactive material on marine species.
April 22 edition	
Nuclear Cleanup to Take Months (vol. 332, p402)	Reports on the nuclear cleanup plans announced by the Tokyo Electric Power Co.
April 29 edition	
U.S. Scientists Map First-Year Radiation Risks (vol.332, p518)	Reports on the risk analysis (conducted by the DOE) over the next year on people living near the Fukushima Daiichi nuclear power plant.

Nuclear Power Stalls in Italy (vol.332, p519)	Reports on Italy's postponement of its nuclear power programs in response to the accidents in Japan.
May 6 edition	
Radiation Standards Draw Protests (vol. 332, p647)	Reports on the resignation of Toshiso Kosako (Professor at the University of Tokyo) as Special Advisor to the Cabinet.
May 13 edition	
Japan Scraps Nuclear Plan (vol.332, p773)	Reports on the announcement of reexamining Japan's energy plans by Prime Minister Kan.
May 20 edition	
Ethics Commission Calls For Swift Nuclear Phase-out (vol.332, p900)	Reports on a leaked draft of a report drawn up by the Ethics Commission on Safe Energy Supply in Germany. The draft includes shutting down of some nuclear power plants in the country.
Fukushima Revives The Low-Dose Debate (vol.332, pp908–910)	Reports on the debate in Fukushima prefecture over allowable levels of radiation, which have come down after the nuclear power plant accidents.
Schoolyard Radiation Policy Brings a Backlash (vol.332, p909)	Reports on the guidelines from the Ministry of Education, Culture, Sports, Science and Technology on allowable radiological contamination in schoolyards and responses to the guidelines from experts and the public.
Crippled Reactors to Get Cooled and Wrapped (vol.332, p910)	Reports on the cooling systems of the Fukushima Daiichi nuclear power plant.
New Work Reinforces Megaquake's Harsh Lessons in Geoscience (vol.332, p911)	Reports on research issues on the mechanism of earthquakes.
Seismic Crystal Ball Proving Mostly Cloudy Around the World (vol.332, pp912–913)	Reports on the trends in earthquake forecasting and the effect of the Great East Japan Earthquake on earthquake forecasting.

different from the official views of the organization. The interview articles included interviews with university teachers and former employees of TEPCO. In the "Commentary" section, four different authors published commentaries. The titles were "Japan Nuclear Accident: Worse than the Worst, Again" (March 12), "Japan's Nuclear Emergency and the Future of Nuclear Power" (March 14), "The Scientific Estate: Bringing the Meltdown Back Home (or) Buddy, Can You Spare an iPad2?" (March 14), and "The Continuing Evolution of Nuclear Power" (March 29). One can understand that the commentaries were written from a wide range of perspectives.

The "Infrastructure," "Search and Rescue Robots," and "Earthquake and Tsunami Warning Systems" also have several reports and explanations on technological and other issues.

4-1-3 Other Academic Organizations in Fields Related to Earthquakes and Nuclear Power Plant Accidents

Academic organizations in fields related to earthquakes and nuclear power plant accidents (for example, geophysics and nuclear power engineering) actively reported, on their websites, on Japan's natural and nuclear disasters, citing news from the media and adding their own analyses.

The ASME (American Society of Mechanical Engineers) published articles in the "News and Articles" section on its website. The titles included "Earthquake Leaves Japan in Crisis," "Rescue Robots Aid Japanese Recovery," "Rebuilding Japan's Railway System," "Tsunami Forces Debate over Vertical Evacuation," "Manufacturing Tested by Japan Earthquake," and "Chernobyl 25 Years Later."

The Seismological Society of America (SSA) has, on the homepage of its website, a link to its Facebook page, where academic and technological reports are posted. During the first month or so after the earthquake, more than 30 articles on the Great East Japan Earthquake were posted. After that, the number of articles on the earthquake decreased, but articles on earthquake prediction and other topics influenced by the earthquake have continued to be posted.

The American Physical Society (APS) published an article about the accidents at the Fukushima Daiichi nuclear power plant by Professor Emeritus David W. Hafemeister from the California Polytechnic State University in the April 2011 newsletter for the Forum on Physics and Society (FPS), one of the many forums of the APS.

The American Nuclear Society provides information

on its website via blog entries and other methods. The following section (4-2. Provision of information to better educate the general public) introduces the ANS "Nuclear Café" blog in detail. The "Nuclear News" in the April newsletter had an 8-page feature article on the Fukushima Daiichi nuclear power plant and reported on the details of the accidents.

To reflect the organization's purpose to use scientific knowledge to develop policies for the creation of a healthy environment and a safer world, the Union of Concerned Scientists set up the "Nuclear Reactor Crisis in Japan" page and posted blog entries (under "All Things Nuclear"), FAQs, briefings to the press, and other information.

4-2 Provision of Information to Better Educate the General Public

In addition to the aforementioned information for researchers, academic organizations also provided information on their websites for the general public, who do not have specialized knowledge.

The American Society for Radiation Oncology had a link on its website's homepage to a three-page article "Radiation Issues Related to the Japan Incident" for the general public The society also had a link to a related article from the Houston Chronicle.

The American Academy of Pediatrics has a link on its website's homepage to "Children's Health Topics," where one could go to the "Children and Disaster" page. One of the topics was "Japan Earthquakes and Nuclear Crisis," which includes information on travel to Japan (the United States Department of State urges U.S. citizens to defer travel to Japan), safety in the United States (there is no health risk for radiation exposure to U.S. residents), and links to federal government organizations (the Department of State, the FDA, FEMA, the CDC, the EPA, the NRC, etc.).

The Health Physics Society has the "Fukushima Nuclear Plant Update" page for its members and the "Ask the Experts–Questions and Answers" page for the general public. On this page, one could find updated answers and questions related to the Fukushima Daiichi nuclear power plant accidents.

The American Psychological Association did not provide related information on its website, but in its newsletter on the Web ("Monitor on Psychology"), the association mentioned that it provided support to those who were, due to the earthquake and subsequent situations, psychologically affected in Japan and the United States.

The "ANS Nuclear Cafe: All Things Nuclear" page managed by the American Nuclear Society set up a page dedicated to the nuclear issues under the title "Fukushima." The page introduces websites of public organizations and the media (both in Japan and the United States) that have released relevant announcements and news. In addition, after March 15, blog entries were updated almost every day (twice a day at first) to keep readers up-to-date on the situation in Japan. The page also kept records of responses to the media made by those who are associated with the society, introduced the Student Section's activities, explained MOX fuel, and posted radiation-related questions and answers.

The Union of Concerned Scientists set up the "Nuclear Reactor Crisis in Japan FAQs" page. It explains, in an easy-to-understand manner, the uptake of radioactive materials, the meaning of "meltdown," cooling issues, and possible health impacts, and provides information on the evacuation area. It also included reasons for the Japanese government's decisions.

5 | Advice and Support for National Policy Making

As discussed earlier, this article does not intend to cover the United States government's responses to the earthquake and the nuclear power plant accidents. In addition, the academic organizations usually do not get directly involved in responses to emergency situations taken by the armed forces, FEMA, the NRC, etc. However, there are cases where academic organizations provide advice and suggestions regarding specific policy themes and where academic organizations conduct research and draw up proposals to support long-term policy making.

The United States is not a parliamentary system. Congress makes policies, being independent from the executive branch that the President presides over. At congressional hearings during this policy-making process, academic organizations may get involved. In particular, after the nuclear power plant accidents in Japan, many hearings were held for committees in both the Senate and the House of Representatives, and not only the legislative branch but also the academic community provided testimonies.

5-1 Proposals to the Japanese and American Governments and Other Related Organizations

Advice and support provided by academic organizations are illustrated below. They are categorized into 1) proposals, 2) reports, and 3) testimonies.

5-1-1 Policy, Scientific, and Technological Proposals

Firstly, some policy proposals were made to the executive branch. For example, Mr. Joe F. Colvin, President of the American Nuclear Society, sent a letter to President Barack Obama to announce the intention to assist the Atomic Energy Society of Japan and the United States government. In the letter, Mr. Colvin also mentioned that "events at the Fukushima Daiichi reactor site continued to evolve rapidly" and that there were "conflicting information and, in some cases, misleading media reports." He urged "policymakers in the administration and Congress to withhold judgments on U.S. nuclear policy until the current situation [had] been resolved and the incident [had] been fully understood."

The Federation of American Scientists (FAS) has links, on its "Nuclear Crisis in Japan" Web page, to the Mr. Colvin's articles published in the media (including the Japanese media). Through these articles, the Mr. Colvin voiced his opinion in March to promote the use of renewable energy. Some of these articles are: "OPINION: Future of nuclear power in Japan: advice from American friend" (Kyodo News Service, March 15) and "Do not phase out nuclear power—yet" (Nature [online version], March 23, 2011).

5-1-2 Posting Previous Reports on the Web and Publishing a New Report by Adding Information during the Printing Process

As I write this article, no concrete policy proposals have been published regarding the recent earthquake and nuclear accidents. Some organizations, however, have republished previous reports or added information during the printing process in order to support the administration.

The National Academies (National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council) were established to "provide expert advice on some of the most pressing challenges facing the nation and the world" to the executive and legislative branches. The Academies did not necessarily respond to the situations right away but rather provided on their website information that was considered useful, judging on past activities. For example, on March 17, the Academies posted their previous reports on the homepage under the title "Japan's Nuclear Crisis" and made them easily accessible to general public. These reports are on nuclear fuel storage, low-level radiation, nuclear accidents, etc. In the past, the Academies have established blue ribbon panels to respond to large-scale disasters in the United States and published reports that have greatly contributed to policy making. After Hurricane Katrina, for example, the Academies drew up and submitted many disaster response and other reports to related organizations. If the Academies recognize this earthquake and the subsequent nuclear accidents to be profoundly related to the United States, it may take similar responses in the future.

The American Academy of Arts & Sciences had a link "Japan Nuclear Power Crisis" on the top page and, on the linked page, published a report titled "Nuclear Reactors: Generation to Generation." Incidentally, the report was already in the process of being printed at the time of the accidents at Fukushima Daiichi Nuclear Power Plant, but information about the accidents was added.

The Union of Concerned Scientists introduced its previous reports , such as "The NRC and Nuclear Power Plant Safety in 2010: A Brighter Spotlight Needed" and "Nuclear Power: Still Not Viable without Subsidies" by posting them on the website.

5-2 Testimony at Congressional Hearings

It is common for witnesses for congressional hearings to be selected in such a way that allows for opinions from different perspectives to be presented, so that the testimony will be useful in discussions for policy making. Not only government agencies such as the NRC and the DOE but also some academic organizations testified at congressional hearings about this particular earthquake, the nuclear power plant accidents, and related energy policies. For example, at the hearing on "The U.S. Government Response to the Nuclear Power Plant Incident in Japan" held on April 6, the NRC, the Nuclear Energy industry, and scientist organizations testified. One scientist testified from the perspectives of environmental and safety issues and another scientist testified as a representative of a nuclear energy society.

Table 2 illustrates the list of congressional hearings

on the earthquake and nuclear power plant accidents during a roughly two-month period. For this article, underlining has been added to indicate the testimony of academic organizations.

During this period, congressional hearings were taking place before the appropriation and other committees in response to the "President's Budget" in February. Some academic organizations, while calling attention to the significance of related research, mentioned the Great East Japan Earthquake and the accidents at the Fukushima Daiichi nuclear power plant, indicating the importance of extending the related budget. However, this report does not cover congressional hearings that are directly related to the appropriations.

6　Academic Research in Earthquake and Nuclear Accident-related Fields

Immediately following the recent earthquake and nuclear power plant accidents, academic research on them has been actively conducted not only in the United States, but around the world. Special sessions were held in some academic conferences and papers including preprint versions were published on the Web.

The Seismological Society of America added a session on the Great East Japan Earthquake and the Christchurch Earthquake at its annual meeting, held between April 13 and 15, 2011. The deadline for new

Table 2: Testimony of Academic Organizations at Senate Hearings (Underlines indicate testimony by persons from academic community.)

Date	Committee	Hearing	Witness/Speaker
March 16	Committee on Environment and Public Works	Nuclear Plant Crisis in Japan and Implications for the United States	Gregory B. Jaczko, Chairman, Nuclear Regulatory Commission Anthony Pietrangelo, Sr. Vice President and Chief Nuclear Officer at the Nuclear Energy Institute Edwin Lyman, Senior Scientist for Global Security at the Union of Concerned Scientists (Note: They spoke as speakers, not as witnesses.)
March 29	Committee on Energy and Natural Resources	To provide an update on the recent events at the Tokyo Electric Power Company's Fukushima Daiichi reactor complex due to the earthquake and tsunami that occurred on March 11	Peter Lyons, Acting Assistant Secretary, Office of Nuclear Energy, U.S. Department of Energy; Bill Borchardt, Executive Director for Operations, Nuclear Regulatory Commission David Lochbaum, Director, Nuclear Power Project, Union of Concerned Scientists Anthony R. Pietrangelo, Senior Vice President and Chief Nuclear Officer, Nuclear Energy Institute
March 30	Energy and Water Development Subcommittee, Committee on Appropriations	Hearing on Nuclear Safety	Peter B. Lyons, Acting Assistant Secretary for Nuclear Energy, U.S. Department of Energy Ernest J. Moniz, Professor of Physics, Massachusetts Institute of Technology David Lochbaum, Director, Nuclear Safety Project, Union of Concerned Scientists William Levis, President and COO, PSEG Power Gregory B. Jaczko, Chairman, Nuclear Regulatory Commission
April 12	Committee on Environment and Public Works	Review of the Nuclear Emergency in Japan and Implications for the U.S.	Lisa Jackson, Administrator, U.S. Environmental Protection Agency Gregory B. Jaczko, Chairman, Nuclear Regulatory Commission Sam Blakeslee, State Senator, California's 15th District James D. Boyd, Vice Chair, California Energy Commission Lewis D. Schiliro, Cabinet Secretary, Delaware Department of Safety & Homeland Security Curtis Sommerhoff, Director, Miami-Dade County Department of Emergency Management Charles G. Pardee, Chief Operating Officer, Exelon Generation Thomas B. Cochran, Senior Scientist, Nuclear Program, Natural Resources Defense Council

| May 5 | Committee on Homeland Security & Governmental Affairs | Understanding the Power of Social Media as a Communications Tool in the Aftermath of Disasters | W. Craig Fugate, Administrator, Federal Emergency Management Agency, U.S. Department of Homeland Security
Renee Preslar, Public Information Officer, Arkansas Department of Emergency Management
Suzy DeFrancis, Chief Public Affairs Officer, American Red Cross
Shona Brown, Senior Vice President, Google
Heather Blanchard, Co-Founder, Crisis Commons |

Note: The titles are based on each committee's information, and the same people may have different titles.

Table 3: Testimony of Academic Organizations at House Hearings (Underlines indicate academic organizations.)

Date	Committee	Hearing	Witness
April 6	Subcommittee on Oversight and Investigations, Committee on Energy & Commerce	The U.S. Government Response to the Nuclear Power Plant Incident in Japan	Martin J. Virgilio, Deputy Executive Director, Reactor and Preparedness Programs, Nuclear Regulatory Commission Donald A. Cool, Senior Level Advisor for Health Physics, Nuclear Regulatory Commission William Levis, President and Chief Operating Officer, PSEG Power LLC (Testified as a representative of the Nuclear Energy Institute) Edwin Lyman, Senior Staff Scientist, Global Security Program, Union of Concerned Scientists Michael Corradini, Chair, Engineering Physics Department, University of Wisconsin-Madison (Testified as a representative of the American Nuclear Society)
April 7	Subcommittee on Technology and Innovation, Committee on Science, Space, and Technology	Earthquake Risk Reduction	Jack Hayes, Director, National Earthquake Hazards Reduction Program (NEHRP), National Institute of Standards and Technology Jim Mullen, Director, Washington State Emergency Management Division; President, National Emergency Management Association Chris Poland, Chairman and Chief Executive Officer, Degenkolb Engineers; Chairman, NEHRP Advisory Committee Vicki McConnell, Oregon State Geologist and Director, Oregon Department of Geology and Mineral Industries
April 14	Committee on Oversight & Government Reform	Tsunami Warning, Preparedness, and Interagency Cooperation: Lessons Learned	William Leith, Acting Associate Director for Natural Hazards, U.S. Geological Survey, U.S. Department of Interior Mary Glackin, Deputy Under Secretary for Oceans and Atmosphere, National Oceanic and Atmospheric Administration, U.S. Department of Commerce Nancy Ward, Regional Administrator - Region IX, Federal Emergency Management Agency, U.S. Department of Homeland Security Kenneth Murphy, regional Administrator - Region X, Federal Emergency Management Agency, U.S. Department of Homeland Security John Madden, Division of Homeland Security and Emergency Management, State of Alaska
May 13	Subcommittees on Investigations and Oversight & Energy and Environment, Committee on Science, Space, and Technology	Nuclear Risk Management	Lake Barrett, Principal, L Barrett Consulting, LLC Brian Sheron, Director, Office of Nuclear Regulatory Research, Nuclear Regulatory Commission John Boice, Scientific Director, International Epidemiology Institute Dave Lochbaum, Director, Nuclear Safety Project, Union of Concerned Scientists

Note: The titles are based on each committee's information, and the same people may have different titles.

abstracts on this topic was March 25.

During the joint meeting held between April 30 through May 3, 2011 by the Pediatric Academic Societies (sponsored by the American Academy of Pediatrics) and the Asian Society for Pediatric Research, there were two sessions on April 30 on the Great East Japan Earthquake and the accidents at the Fukushima Daiichi nuclear power plant as well as on the Gulf of Mexico oil spill.

At 2011 IEEE International Conference on Robotics and Automation (ICRA 2011) (held in Shanghai between May 9 through 13, 2011), IEEE Robotics and Automation Society held the ICRA Special Forum: Preliminary Report on the Disaster and Robotics in Japan. The organizer of this forum was Professor Yoshihiko Nakamura from the Graduate School of Information Science and Technology at the University of Tokyo, and the panel included four Japanese researchers.

The American Nuclear Society is planning to hold some special sessions on the Fukushima Daiichi nuclear power plant during its annual meeting between June 26 and 30, 2011: Special Session: The Accident at Fukushima Daiichi—Preliminary Investigations–Panel; Public Information Workshop: Communicating with Policy Makers and the Public After Fukushima Daiichi”; ANS President's Special Session: “Fukushima Update and Lessons Learned”; and Standards Symposium. However, there is no information about additional applications for general speakers.

In addition, American and international academic conferences on earthquake/tsunami, radiology, and nuclear power engineering are planning to hold separate sessions on the Great East Japan Earthquake. Some conferences have changed their schedules, and others have postponed the deadlines for abstracts.

During the first two months after the earthquake, there were few academic articles appearing in peer-reviewed journals, but related articles have already appeared in preprint versions and open access repositories. For example, arXiv is a site currently managed by the Cornell University Library, and some of the articles have been published, including the ones by Japanese researchers. It is not clear whether these articles could be considered to be equal to articles of journals published by established academic organizations, but this example suggests that the American academic community provided an opportunity for researchers to submit papers on this particular earthquake and nuclear accidents.

7 | Behind American Academic Organizations' Responses

The previous sections cover American academic organizations' responses to the Great East Japan Earthquake. These responses were, in great part, made possible due to the characteristics of these organizations and changes in the environment of international academic research. The following sections introduce the environment for such responses.

1) American Academic Organizations Have Strong Management Bases

Most of the academic organizations covered by this article are relatively large in scale and have strong management bases. For example, since immediately after the earthquake, IEEE has been able to have contributors stay in Japan to provide daily reports on the situation. The Union of Concerned Scientists publishes many reports and has the capacity to conduct its own research to be able to testify to Congress. There are many individual members, both researchers and non-researchers, who support its activities financially and in other ways. The union also receives funds from groups and organizations.

2) Significance of the Impact of the Great East Japan Earthquake on the United States

The Great East Japan Earthquake occurred far from the United States, and the only immediate risk was tsunamis along the Pacific Ocean. However, the United States took the disasters very seriously in the broad framework of natural disasters and energy policy, which has led academic organizations to take action. In that sense, the situations are similar for both the American and Japanese academic communities, but it should be noted that the Japanese academic community has been directly affected in some ways. There may have also been cases where the Japanese academic organizations were advised to be selective about releasing some information in order to avoid social unrest.

3) Characteristics of Information on the Internet Provided by American Academic Organizations

Information provided on the Internet by academic

organizations was instantaneous and diverse, unlike information through conventional print media.

It should be noted that many academic organizations reported the breaking news of the earthquake on their websites on March 11 despite the time difference and, soon after that, posted words of condolence and concern. It should also be noted that swift action was taken to provide up-to-date information of great public concern, such as tsunami forecasting and the conditions of the nuclear reactors at the Fukushima Daiichi nuclear power plant.

It is also noteworthy that individuals have been able to post information and opinions on academic organizations' websites with the authors' names through blogs and other forums. Individual blog entries did not necessarily agree with the academic organization's stance. However, these entries are presented along with official reports and opinions, and so information is provided to researchers and the public from diverse perspectives. Taking this into account is helpful when considering the ways in which Japanese academic organizations are managed.

8 | Conclusion: Roles of the Academic Community to Respond to Disasters

The previous chapters cover the activities conducted by the American academic community in response to the Great East Japan Earthquake and subsequent tsunami and nuclear power plant accidents. As a conclusion, this article categorizes the roles of academic community into four groups.

1) Information Sharing

Since most of the information from Japan was in Japanese, many American academic organizations provided information in English to researchers and the public from an academic point of view. During the process, some academic organizations often added their own analyses and interpretations. These activities not only contribute to the development of academic research but also address the public's concerns.

2) Support to the Public

This particular earthquake and the subsequent nuclear accidents did not directly affect the United States. Therefore, most of the support by academic organizations was done in the form of providing American public with related information and attempting to address their concerns. Some organizations announced their determination to support Japanese academic organizations and conducted fundraising.

3) Contribution to Policy Making

In the medium and long terms, American academic organizations have been contributing to policy making to respond to large-scale disasters. After Hurricane Katrina, the National Academies published reports. Analyses and advice were provided to support policy making from an academic point of view. Similar action is expected to be taken to respond to these particular disasters as well. Academic organizations are capable of both medium- and long-term support to policy making as well as short-term responses, including providing testimonies at congressional hearings after disasters.

4) Development of Swift and Open Academic Research

Researchers in the United States and around the world quickly began conducting research in response to the disasters. One contributing factor is that information can be exchanged instantaneously using the Internet. Academic organizations play a great role as an intermediary to promote such swift and open research activities, and the role is expected to become greater.

It is not directly related to these particular disasters, but after Hurricane Katrina, the United States government increased the support for research activities by flexibly providing research funds and allocating additional funds. This experience may have encouraged the American academic community to quickly respond to the disasters in Japan. The Japanese government also began taking a variety of actions in response to the disasters. The academic community's activities and cooperation between the community and the policy makers are expected to lead to the further development of academic research in Japan.

Outlines of the Academic Organizations Mentioned in this Article

- National Academies: http://www.nationalacademies.org/

  The National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council make up the National Academies.

- American Academy of Arts & Sciences: http://www.amacad.org/

  The academy, founded in 1780, consists of leaders from different academic disciplines and is an independent policy-research center that conducts multidisciplinary studies. There are about 4,000 members.

- American Association for the Advancement of Science: http://www.aaas.org/

  AAAS, founded in 1848, is a non-profit organization dedicated to advancing science for the benefit of all people. It publishes the journal Science.

- IEEE: http://www.ieee.org/

  IEEE was originally founded as the American Institute of Electrical Engineers (AIEE) in 1884. It is now the world's largest professional association (about 400,000 members) dedicated to advancing technological innovation and excellence for the benefit of humanity. IEEE is organized into many sections, chapters, societies, councils, and branches covering a wide range of fields relevant to engineering. For example, there are 38 societies organized by field.

- ASME: http://www.asme.org/

  ASME is a non-profit organization founded in 1880 by machine builders and technical innovators. There are more than 120,000 members in all engineering disciplines from around the world.

- American Chemical Society: http://www.acs.org/

  ACS is an academic organization in chemistry founded in 1876. There are more than 163,000 members around the world.

- American Crystallographic Association, Inc.

  ACA is a non-profit, scientific organization of more than 2,200 members founded in 1949 through a merger of the American Society for X-Ray and Electron Diffraction (ASXRED) and the Crystallographic Society of America (CSA).

- SPIE: http://spie.org/

  SPIE, founded in 1955, is an international academic organization to advance optics and light-based technologies, serving approximately 180,000 constituents.

- American Physical Society: http://www.aps.org/

  APS is an academic organization for physics founded in 1899. There are 46,000 members from a wide range of physics disciplines.

- Seismological Society of America (SSA): http://www.seismosoc.org/

  SSA is an academic organization founded in 1906 to promote research in seismology, promote public safety, protect the community against disasters due to earthquakes and earthquake fires, and inform the public for better understanding of the risks of earthquakes.

- American Geophysical Union: http://www.agu.org/

  AGU was established in 1919 by the National Research Council and is now an independent non-profit corporation for geophysics. There are more than 60,000 members in 148 countries.

- American Academy of Pediatrics: http://www.aap.org/

  AAP, founded in 1930, is an organization of 60,000 pediatricians.

- Health Physics Society: http://hps.org/

  The society, formed in 1956, is a scientific organization of professionals who specialize in radiation safety. There are nearly 5,000 members.

- American Society for Radiation Oncology: http://www.astro.org/

  ASTRO, founded in 1958, is an organization of about 10,000 radiation oncologists, radiation oncology nurses, medical physicists, radiation therapists, dosimetrists, and biologists to advance the practice of radiation oncology.

- American Society for Cell Biology: http://www.ascb.org/

  ASCB, founded in 1960, is an academic organization of approximately 10,000 members in cell biology.

- American Psychological Association: http://www.apa.org/

  APA, founded in 1892, is an organization of more than 154,000 psychologists and other professionals to advance the creation, communication, and application of psychological knowledge to benefit society and improve people's lives.

- Society for Neuroscience: http://www.sfn.org/

  SFN, founded in 1969, is an academic organization of more than 40,000 scientists and physicians who study the brain and nervous system.

- American Nuclear Society: http://www.new.ans.org/

  ANS, a not-for-profit, international, scientific and educational organization, was founded in 1954 to unify professional activities within the diverse fields of nuclear science and technology. Its membership is composed of approximately 11,000 engineers, scientists, administrators, and educators representing 1,600 plus corporations, educational institutions (universities, etc.), and government agencies.

- Federation of American Scientists (FAS): http://www.fas.org/

  FAS was founded in 1945 by many of the scientists who built the first atomic bombs in 1945. FAS emphasizes the ethical obligation of scientists, engineers, and other technically trained people and the importance of the application of technological fruits for the benefit of humankind. In addition to the founding mission of preventing nuclear war, the organization has expanded its work to include bio-security and other issues. FAS is a think tank.

- Union of Concerned Scientists: http://www.ucsusa.org/

  UCS, founded in 1969, is a science-based non-profit organization that combines independent scientific research and citizen action, working for a healthy environment and a safer world. Its membership is composed of more than 250,000 citizens and scientists.

Profile

Satoru ENDO
Affiliated Fellow, Science & Technology Foresight Center
Professor (Management), University Management Center, Tokyo Institute of Technology

Mr. Endo studies science policy in the United States and elsewhere. In 2000, while working for Japan Society for the Promotion of Science, he established a website titled "Science Policy in the United States" (in Japanese) and has been providing information on policy trends. At Tokyo Institute of Technology, Mr. Endo has extended his study to include the relationship between science and society as well as higher education.

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[Reference]

Initial Responses Taken
by Japanese Academic Organizations

Science & Technology Foresight Center

The Science Council of Japan (SCJ) website lists 1,864 academic research organizations (as of May 31, 2011). The following sections present external activities conducted by these organizations during the initial roughly two-month period immediately after the earthquake. The makeup of the organizations by field are not clear, but according to the directory of academic organization (2007–2009 version, published by Japan Science Support Foundation) in which 1,767 organizations are listed (slightly different from the SCJ's list), literature, philosophy, education, psychology, sociology, and history make up of 31%; law and political science make up 3%; economics, commerce, and business make up 7%; sciences make up 11%; engineering makes up 10%; agriculture makes up 9%; and medicine, dentistry, and pharmaceutical sciences make up 29%.

1 | Activity Content

Activities conducted by these organizations can be categorized into: expression of condolence and concern; policy announcements; establishments of new offices, etc.; provision of information; collection of information (request for provision of information);

support activities; and discussion and reviews (see Reference Table 1). More specifically, these activities included: providing information in multiple languages and recruiting volunteer translators; preserving records of the damage; providing information about receiving researchers and keeping samples; providing information about radiation and geological conditions; dispatching civil engineering-related investigation teams and providing technological support; dispatching medical and psychology professionals and providing clinical support (providing handling information by condition, providing information about facilities that can take in new patients, and making arrangements to acquire medicines); and providing information on the impact of radiation, infectious diseases, and health management.

2 | Activity Status

This section focuses on external activities except for expressions of condolence and concern, announcements of policies, and collections of information about the well-being of the members of their organizations.

About 20% of the organizations took some concrete

Reference Table 1: Activity Content

Expression of condolence & concern	Expressions of condolence and concern were published separately or in notices of meeting cancellations. Expressions of condolence and concern from related academic organizations overseas were also published.
Policy announcement	Policies to respond to the disasters were published separately or along with expressions of condolence and concern. (Some announced concrete policies and others just announced their determination to examine their role in society.)
Establishments of new offices, etc.	Committees to deal with the disasters, special Web pages, etc. were established.
Provision of information	Research-related information (regarding providing places for research, keeping samples, etc.) for affected researchers as well as specialized information for victims and supporters were provided.
Collection of information	Information about the well-being of the members of the organizations and information about affected areas (investigation teams, etc.) were provided.
Support activities	Specialist support was provided (dispatching specialists, setting up consultation services, providing technological support, etc.). Arrangements for necessary items were made. Research support was provided (subsidies for related research, etc.). Donations were raised.
Discussion & reviews	Proposals were made. Meetings were held. Special articles were published in organizations' journals.

*Exempting membership fees for affected members can also be interpreted as research support in a broad term, but it is not included here.

action. Most noticeably, many organizations began working with the Japan Medical Association, companies, and related associations right after the earthquake to dispatch healthcare professionals and to make arrangements for medicine and equipment. Civil engineering-related investigation teams were also dispatched. In April, many activities were initiated. Symposiums and emergency meetings to discuss future activities were held in May and afterward.

Most published information was specialized for victims and supporters (about 50% of the organizations that took concrete action published such information). These organizations provided not only their own information but also links to other websites, trying to provide as much information as possible. Also provided was information on providing opportunities for discussion, such as meetings and special editions (about 20%), And information on support activities by specialists, such as dispatching specialists, establishing consultation services, and providing technological support (about 20%).

About 40% of 535 organizations that have more than 1,000 full members conducted activities. Characteristically, economic organizations held discussions and conducted reviews; organizations related to medicine, dentistry, and pharmaceutical sciences provided information; and science organizations provided research information for victims (about half the organizations that took concrete action did this). As to discussions for future activities, economic organizations often held special sessions at conferences, and organizations related to sciences, engineering, agriculture, medicine, dentistry, and

pharmaceutical sciences held separate symposiums and lectures.

3 | Cooperation between Academic Organizations

Some academic organizations worked together to respond to the disasters. Reference Table 3 illustrates such activities.

Reference Table 2 : Responses by Area of Study

Area	No. of organizations	% of organizations that took action**	% of activities by content**		
			Provision of specialized information	Responses by specialists	Discussions & reviews
Literature, philosophy, education, psychology, sociology, history	82	27%	41%	32%	18%
Law, political sciences*	4	—	—	—	—
Economics, commerce, management*	17	18%	0%	0%	75%
Sciences	55	47%	38%	8%	31%
Engineering	86	27%	30%	22%	35%
Agriculture	29	41%	33%	8%	33%
Medicine, dentistry, pharmaceutical sciences	262	46%	69%	25%	4%
Total	535	39%	55%	22%	15%

*The number of organizations is small, so the percentages are not indicated.
**The percentages are approximate figures. 0% means that the percentage is less than 10%.

Reference Table 3 : Cooperation between Academic Organizations

Title	Related academic organizations
Psychological Support Center for the Great East Japan Earthquake	Japanese Society of Certified Clinical Psychologists, Association of Japanese Clinical Psychology, Foundation of the Japanese Certification Board for Clinical Psychologists
Robotics Task Force	Japan Robot Association, the Japan Society of Mechanical Engineers Robotics and Mechatronics Division, SICE System Integration Division, IEEE Robotics and Automation Society (Japan)
Liaison Committee among JAEE, JSCE, AIJ, JGS and JSME on the Tohoku-Pacific, Japan Earthquake	Japan Association for Earthquake Engineering, Japan Society of Civil Engineers, Architectural Institute of Japan, the Japanese Geotechnical Society, the Japan Society of Mechanical Engineers
Joint emergency statement	Japan Society of Civil Engineers, the Japanese Geotechnical Society, City Planning Institute of Japan
Joint appeal issued by related academic organizations	The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan, Japan Society of Civil Engineers, Japan Concrete Institute, City Planning Institute of Japan, Japanese Geotechnical Society, Architectural Institute of Japan, Japan Institute of Landscape Architecture
Joint president statement "Japan will not stop progressing scientifically"	34 societies (440,000 members)