Development of Multi-functional Seismic Information System for the Public Communication on Nuclear Safety

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SUMMARY:
The aim of this study is to develop an information system which contribute to enhancing a nuclear safety regulations in terms of an information dissemination in order to mitigate serious disaster such as Fukushima Dai-ich accident. Technical standards for disseminating a seismic safety information of nuclear facility as well as nuclear risk information in an emergency, and risk communication in normal times are needed. This study examines the framework, contents, and technical basis for developing an information system. In addition, this study identify the communication issues concerning the seismic safety based on the lessons learned from the Fukushima Dai-ich accident through the testing information systems in areas around nuclear facilities and by providing effective implementation guidelines. This study examines solutions to communication problems that emerged after the earthquake by applying the concept of RARMIS (Risk-Adaptive Regional Management Information System) to communication against the external events. Furthermore, a general outline of the system, its functions established so far, and studies on these functions as effective communication tools are introduced.

Keywords: Seismic Information system, Nuclear Seismic safety, Risk communication, Public, Human interface

1. INTRODUCTION

During the Great East Japan Earthquake that struck on March 11, 2011, all reactors of the Fukushima Dai-ichi Nuclear Power Plant were automatically shut down, but lost their cooling capability due to the subsequent tsunami. This resulted in the off-site release of radioactive materials from the containment structures, and many local residents were forced to evacuate from the area.
The earthquake and tsunami devastated a vast area, including much of the social infrastructure including electricity and communication lines. These damages led to loss of communication function. As a result, there was insufficient information on the status and risks of the nuclear power plant, even though the local government and residents in the evacuation zone desperately needed such information. Insufficient information concerning potential events and phenomena, particularly threats to the lives and property of local residents, caused great distress to the disaster victims both mentally and physically.
The Off-site Center which provides information to local governments and residents, was unable to operate following the earthquake and tsunami because the communication system had been built assuming that major natural and nuclear disasters would not occur simultaneously, yet the scale of the earthquake and tsunami was far beyond the assumption. Nevertheless, communication with local residents is one of the most important elements of crisis management, and reliable communication should have been guaranteed.
The shortcomings of communication systems affected the disaster response by experts as well. the disaster disabled the plant monitoring and communication facilities at Fukushima Daiichi, so the plant's evolving status could not be monitored.
In the accident, not only was the communications infrastructure affected, but also information could not be systematically collected, shared and transmitted. Accordingly, Japan was criticized for inadequate information disclosure to other countries.

A report of the Japanese Government containing 28 lessons learned from the above and other experiences of the Fukushima Dai-ichi accident was submitted to the International Atomic Energy Agency (IAEA). In addition to lessons learned concerning improvement of nuclear safety against earthquake and tsunami, the report highlights the importance of information sharing and risk communication.
There is an urgent need to make improvements of structural integrity against severe accidents and ensure robustness against tsunami. In addition to these technical challenges, the public perceive the urgent need for the communication of information and risks. Establishing communication links to ensure accountability and transparency concerning nuclear safety is a major challenge for raising the safety culture among people in the nuclear society.

2. OBJECTIVES

Except for the fire authorities, etc. for which emergencies are within the normal scope of work, the systems for communicating emergency information have repeatedly been shown to be ineffective in major disasters in Japan. In response to the Great Hanshin-Awaji Earthquake in 1995, Kameda et al. proposed the RARMIS (Risk-Adaptive Regional Management Information System) concept. This concept details requirements such as ensuring the robustness of communication in an emergency by adopting an autonomous decentralized information management system and guaranteeing reliable communications in an emergency by using conventional systems that are daily used.
The Niigataken-Chuetsu-Oki Earthquake (NCOE) occurred on July 2007 that caused damages to the Kashiwazaki-Kariwa Nuclear Power Station. In the NCOE, the plant situation was not transmitted promptly. The loss of information sharing between local community and related organizations caused the public anxiety. The importance of plant information transmission as well as seismic information gathering were recognized. Specific recommendations for information dissemination were identified by the Japanese Government Committee. One of the important providing point is a dissemination of easy-to-understand information in an ingenious representation. Since 2007, Japan Nuclear Energy Safety Organization (JNES) has developed the advance model of the communication system for seismic safety and security that cooperated with local communities based on the practical experience, which realized by communication technology and methodology.
Revised Nuclear safety regulations in terms of an information dissemination in order to mitigate serious disaster such as Fukushima Dai-ich accident are required. And to do that, technical standards for disseminating a seismic safety information of nuclear facility as well as nuclear risk information in an emergency, and risk communication in normal times are needed (Figure 1).

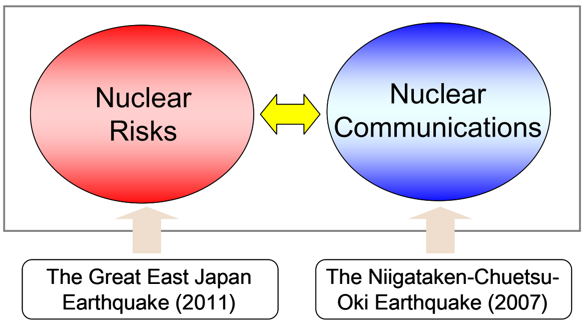

Figure 1. The horizons of this study

This study examines the framework, contents, and technical basis for developing an information dissemination and communication system. In addition, this study contributes to improve the nuclear safety regulations based on the lessons learned from the Fukushima accident through the testing information systems in areas around nuclear facilities and by providing effective guidelines.
This report also discusses solutions to communication problems that emerged after the earthquake by applying the concept of RARMIS to communication against external events. Furthermore, a general outline of the system on these functions as effective communication tools are introduced.

3. REQUIRED ELEMENTS OF INFORMATION SYSTEM

3.1. Framework for communication of seismic safety information

The official website of the Prime Minister’s Office concerning the response to the disasters caused by the 2011 Great East Japan Earthquake describes the role of risk communication as follows:
“ In a large-scale and compound disaster, the risk management capabilities of the government are limited, and self-help efforts by local communities and residents are crucial. It is important to clarify the indispensable roles of the government, experts, companies, and residents, and to establish a common awareness of risks and collaborative relationship among these parties. The objectives and role-sharing of risk communication differ in normal times, in an emergency, and in the recovery process.”
In this study, measures to enable a seamless shift between communication in “normal times” and “in an emergency” are discussed based on the concept of RARMIS.
Figure 2 shows the flow of information concerning nuclear safety. Information is disseminated to the local residents around nuclear facilities through municipal news reports in normal times and through disaster administration radio communications in an emergency. Information is disseminated by regulators through newsletters, websites, and e-mails in both normal and emergency times. In this framework, communication between regulators and citizens is conducted mainly through public meetings.

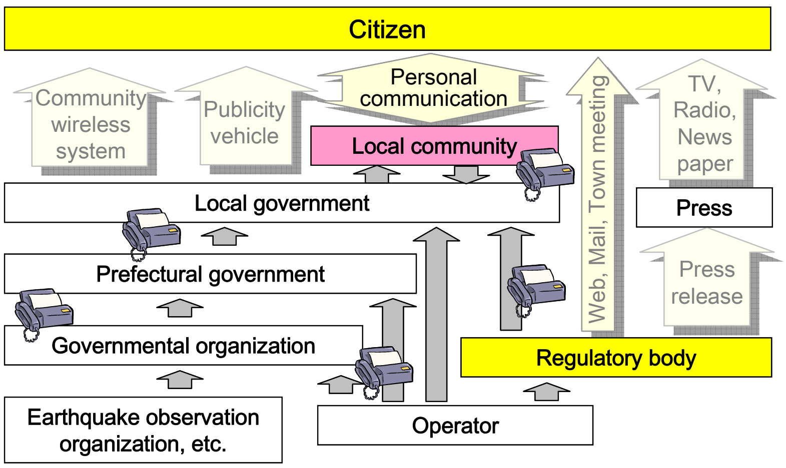

Figure 2. Flow of information concerning nuclear safety

In many of the areas around nuclear facilities in Japan, the local communities are functioning effectively. These communities provide venues for communication among residents and assistance to individual residents. Community residents without good access to information are supported by the other members on a daily basis, and bidirectional communication between local governments and citizens is supported by the communities.
If there is a single information source in the area of a nuclear facility, it is unrealistic to establish on-demand bidirectional communication of information for every citizen. A realistic solution is to incorporate self-help with mutual help.
Therefore, as end-users of the information system developed in this study, information sender are defined as regulators, and information recipients are defined as local communities as well as local governments.
Communication between a local community and citizens is done by personal communication among citizens. Therefore, from the aspect of functional requirements, citizens’ needs are aggregated at the local community level, so it is sufficient to ensure bidirectional communication between the regulators and dozens of local communities.
After the Fukushima accident, telephone call centers were set up to provide advice to the public. Many staff at the telephone call centers worked hard on the important job of communicating with the public.

In addition, to provide more detailed information to evacuees from the plant vicinity and identify their needs, information should be communicated through links with the existing framework of the local community.
The technical feasibility of such communication can be ensured by employing ad-hoc combined of routine application equipment and facilities such as notebook PCs, battery units on automobiles, and radio communication units as information terminals for the local community.

3.2. Contents of communication

In emergencies in Japan to date, the main focus of communication has been to transmit confirmed information. Many of those who distribute such information explain the reason as being to prevent anxiety and confusion among citizens caused by providing uncertain information.
In addition, the main focus in communicating safety has been to describe criterion measures. The risk communication depicted in lessons learned from the Fukushima accident should be distinguished from one-sided "transmission of risk information." At the same time, imperatives (Stallen & Coppock, 1987) are imposed on the party providing the information, i.e. the regulators.
These obligations are in response to the expectations of the public that regulatory agencies regulate nuclear and other risks effectively and efficiently, and that the public are informed that these obligations have been appropriately met.
In risk communication in normal times, which is the subject of this study, useful information from earthquake and tsunami PSA (Probabilistic Safety Assessment) is used.
In PSA, the probability that the reactor containment is damaged by a combination of multiple damages to facilities is evaluated in consideration of every earthquake and tsunami that may affect the nuclear power plant. As result of this evaluation, median and average values are provided, as well as the range of uncertainty.
For example, by using extract useful information from PSA, the risk reduction effects of measures to counter accident sequences of structures, equipment and safety systems can be quantitatively demonstrated in the accident management of a nuclear power plant.
In local areas of nuclear facilities, by conducting risk communication to explain risk reduction measures and their evidence in a scientific and logical manner on a routine basis, it is expected that mutual trust among related parties can be built and strengthened.
In addition, conducting risk communication on a routine basis will enhance information sharing and communications literacy among experts and the general public.

3.3. Technical bases for information communication

The post-earthquake integrity of a plant is evaluated based on the seismic forces applied to the important safety equipment and facilities of the plant. For a more precise evaluation, it is necessary to acquire seismic waveforms observed at the nuclear power plant. However, earthquake observation data for Fukushima Dai-ichi were not publicly released until June 2011, three months after the earthquake.
During the immediate post-quake period, because of the lack of observation data from the plant operator, JNES which is a regulatory-affairs technical support organization (TSO), tried to conduct an evaluation using seismic waveforms measured around the Nuclear power plant site. However, it was very difficult to collect data from seismologic institutions due to data access congestion and damage to relevant observed data servers.
Furthermore, because the disaster was caused by multiple events, namely the earthquake and the Fukushima accident, there was a clear need for integrated handling of information such as plant status and radioactive release and dispersion.
In general, each expert institution has its own observation and evaluation systems, and cannot use the evaluation results of other institutions. Therefore, information such as earthquake and/or tsunami disaster information within and around the plant site and release and fallout information of radioactive materials was not effectively handled together for crisis management.
After the 2004 Sumatra Earthquake and tsunami, JNES developed the TiPEEZ (Protection of NPPs against Tsunamis and Post Earthquake considerations in the External Zone) System (Ebisawa,K.,

Yamada, H. et al. , 2008), which has a platform function for integrated processing and sharing of information such as “integrity evaluation of the plant and its external areas in an earthquake and tsunami” and “evaluation of evacuation plan with consideration of the spread of radioactive materials as well as damage to transportation routes in the site external areas.”
The TiPEEZ System had already been provided to member states of the IAEA through the IAEA free of charge in 2010. However, the system has not been effectively used in Japan because, although it is conceptually effective, the elemental technology of the information system still has many challenges to overcome for practical and widespread use.
Even if the introduction of the new system is accepted technically, operational tasks such as concurrent use and/or linkage of the new and existing systems or replacement of existing systems with the new one must be performed.
In this study, risk communication functions are structured on the platform common with TiPEEZ. In addition, to apply the system to local areas of nuclear facilities, effective introduction and operation processes of the system are derived through studies within the framework of the local industry, governments, and academia.

4. DEVELOPMENT OF SEISMIC INFORMATION COMMUNICATION SYSTEM WITH FUNCTIONS FOR THE BOTH NORMAL AND EMERGENCY TIMES

Figure 3 outlines the seismic information system having functions for normal times as well as emergency. The system contains functions for collecting seismic observation data of nuclear facilities and their neighbouring area and for collecting information concerning the integrity of plants. The collected information is integrated into a database and promptly provided to experts at relevant institutions.
In addition, the information is provided to local residents and the public in easy-to-understand formats such as visual forms. Although not shown in figure 3, the system also contains a bidirectional communications function for risk communication with local citizens.

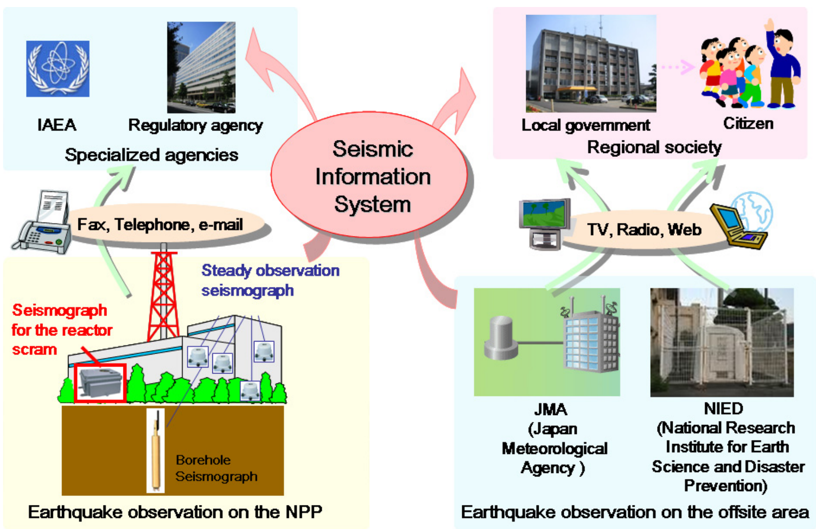

Figure 3. Outline of the seismic information system having functions for normal times as well as emergency

4.1. Development of information communication function for experts

Figure 4 shows information gathering and transmitting of this system. There are seismic station of multiple institutions including the operator located within and in the neighbourhood of a nuclear site. For integrating data gathered from multiple institutions and for utilizing the data effectively, a mechanism is needed to process data for integration.

As of the end of March 2012, this system is able to collect observation data within a 50-km radius from a nuclear site taken by multiple seismic observation institutions such as the National Research Institute for Earth Science and Disaster Prevention (NIED) and the Japan Meteorological Agency (JMA), as well as to integrate and manage the observation data from multiple institutions on each event. In addition, a waveform analysis function to improve the integrity evaluation of plants has been developed. A function for adding seismic observation data of indoor and outdoor locations at nuclear sites has also been established for the future when such data become available from utilities.
In addition, functions to collect estimated distribution data of seismic motions evaluated by the National Institute of Advanced Industrial Science and Technology (AIST) and to distribute the data to the International Seismic Safety Centre (ISSC) of the IAEA have been established. Data have been distributed to the ISSC since November 2011, contributing to activities by IAEA ISSC.
The integrated database covering areas in the vicinity of nuclear sites in Japan will be released to the IAEA as well as relevant Japanese institutions involved in safety regulations.

4.2. Development of information communication function for the general public

It has been pointed out that the objective of nuclear risk communication has shifted from acceptance-building to confidence-building following the experiences of the Chernobyl accidents and Fukushima accidents (Kitamura, 2012).
Prof. Kitamura also pointed out that the introducing the human interface technology is effective in a situation where communication related to nuclear risks is difficult.
This study examined how to implement effective communication. In addition, as a human interface for bidirectional information communication has been developed. A trial function for integrating and generating a knowledge database of communicated information has been conducted. The functionality of this trial function has been confirmed in an area near a nuclear facility.

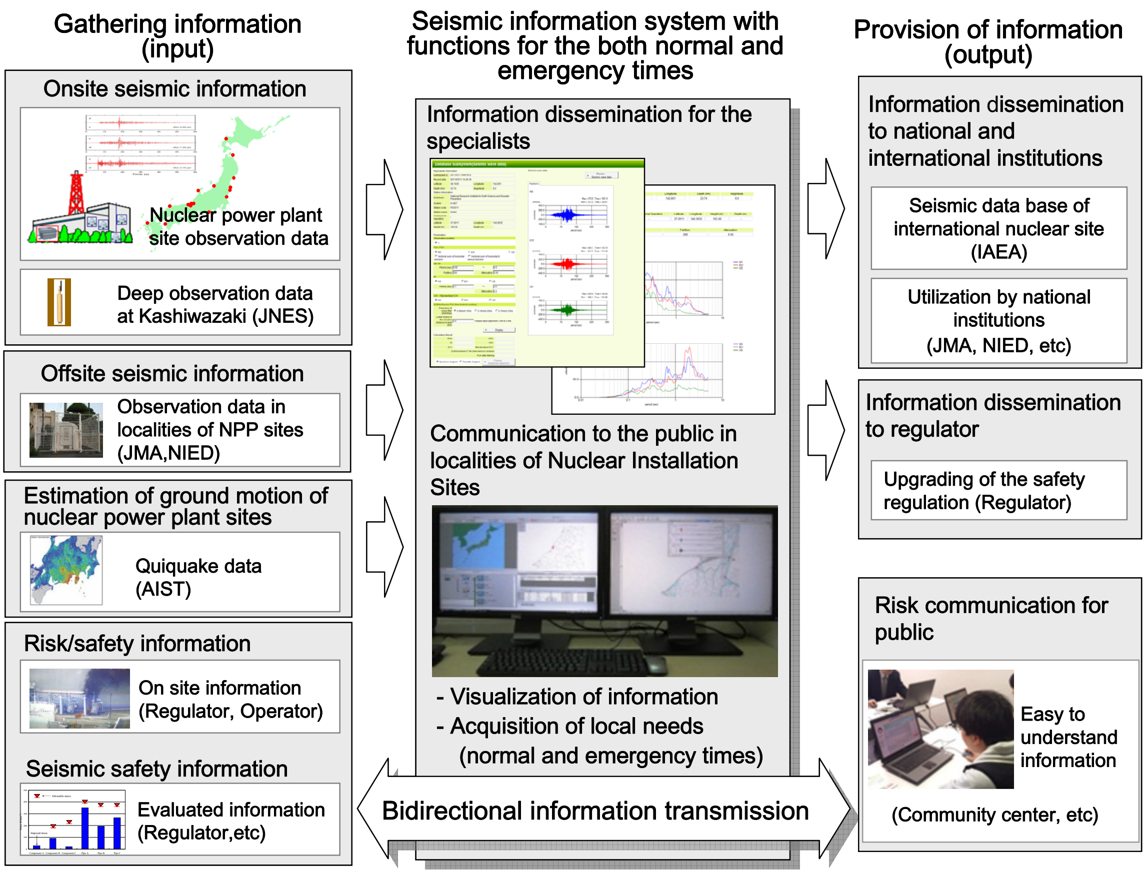

Figure 4. Information gathering and transmitting of seismic information system

4.2.1. Examination of human interface function for risk communication

Figure 5 shows the concept of human interface in risk communication. A repository function for risk communication is incorporated into the system on the side of the party sending out information. The repository function consists of a database of useful information for evaluating earthquake and tsunami PSA and a knowledge database for communicating evidence appropriately in risk communication.

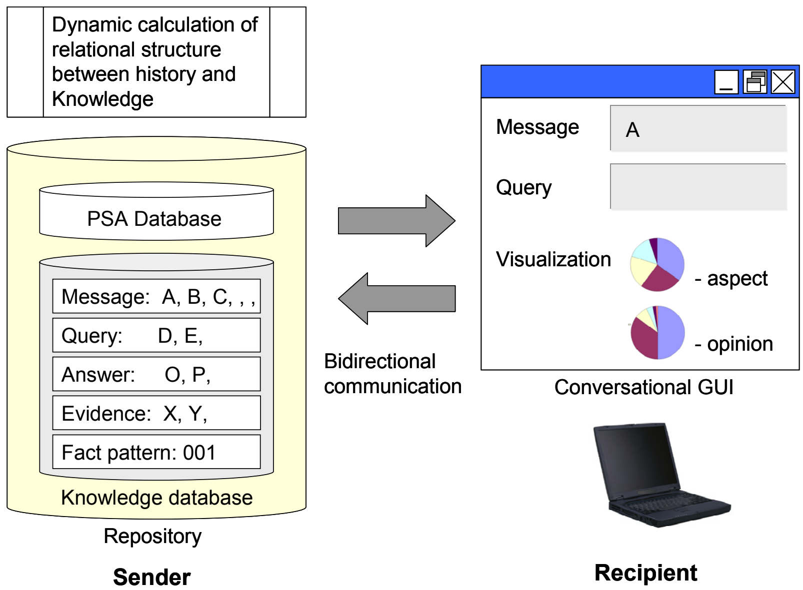

Figure 5. The concept of human interface in risk communication

Historical information as well as connection information of exchanges between “senders” and “recipients” of information are provided and stored in the knowledge database. When designing the metadata structure and functions of the knowledge database, it is necessary to construct a function to minimize the dissociation between the contexts of “senders” and “receivers” of information by accumulating risk communication between multiple “senders” and “receivers” on a daily basis. This information processing has been examined in the joint research program with the Niigata Institute of Technology (NIIT) as the communication model named “Kashiwazaki Kariwa Model” in the vicinity of the Kashiwazaki-Kariwa Nuclear Power Station (NPS), which experienced the 2007 Niigata-ken Chuetsu-oki Earthquake.

The functions of the knowledge database are planned to be structured based on the “Kashiwazaki Kariwa Model”.

4.2.2. Examination and trial of human interface of the recipients of information

In order to develop an information system into a tool for daily bidirectional communication, it is necessary to gain the acceptance of end-users of the system, and so an easy-to-use interface is essential. In this study, a trial interactive operation interface for recipients of information that enables operation without manuals was built.

In this system, information communicated from a sender to recipients as well as questions and opinions from the recipients are sorted in the repository of the sender.

The human interface technology suggested by Kitamura requires the capability to look up previous information related to questions as well as accurate presentation of evidence. In addition, real-time visualization of opinions and impressions expressed by the recipients of information is effective.

It seems difficult to build such information processing with a Relational Database Management System (RDBMS), which is a common database with a static structure. To create such functions in future, it is necessary to build a function to process information on a knowledge database that can calculate the relational structure dynamically while securing real-time processing in bidirectional communication.

4.3. Functional verification of human interface for recipients of information

While the objective of this study is to improve and enhance a nuclear safety regulations in terms of an information dissemination, the final goal is not only to create the technical basis for communication but also to present guidelines for its actual implementation.

In general, the information system developed by government expense. The designing and development works which are mainly carried out by vendors. Observation of the actual use of such a system in the field suggests that the needs of end-users are not necessarily reflected on the system.

When reviewing the application of this system, it is important to establish a process to ensure that the local culture and regional peculiarities are reflected on the communication tools and that the system is adjusted to and utilized by local industry, government, and academia. This process is outlined below.

First, platform software for realizing communication is provided free of charge as public support to the local area. This provides a common protocol for sharing information, data structure, and basis for information processing in the local area. Then, through industry-government-academia cooperation in the local area, functions unique to the area are added to the platform based on local needs.

By keeping the framework suggested in Section 3.1 functioning in normal times, the system is expected to be used in all phases: normal times, emergency, and recovery period.

It is important not to limit the purpose of using this system to the nuclear society, but also to use the system as a communications tool for local governments, local communities and residents. To achieve this, coordinated efforts among local industry, government, and academia are necessary.

JNES owns a research center (JNES Kashiwazaki Seismic Safety Cente) in the city of Kashiwazaki. The Kashiwazaki is a nuclear site and that experienced the 2007 NCOE. This research center is also serving as a base for joint research activities with local universities and JNES.

This report outlines functional verification tests conducted for confirming the elementary functions developed so far by taking the local communities in Kashiwazaki city as recipients of information.

An information transmission test using a public internet line was carried out between JNES Kashiwazaki Seismic Safety Center and Kashiwazaki City Community Center located approximately 5 km away. Figure 6 shows the functional verification test being conducted.

At the community center, local citizens and local government staff communicated information mainly concerning the earthquake bidirectionally by using an interactive interface. Positive reactions were gained concerning the framework by taking local communities as end-users. The following three elements may be reasons for the positive reaction: 1) There already exists a framework of mutual support underlying regional self-help capabilities in the Kashiwazaki area; 2) People in the area are highly aware of the issue following the Chuetsu-oki Earthquake; 3) The concept of this system matches the needs of the local community.

In the functional verification test, operability without manuals was also confirmed. Furthermore, through the positive opinions expressed by participants of the test, information on users' needs which is useful for improving the human interface was acquired. In the future, for analyzing the needs, additional tests are planned to be conducted with the participation of more local communities.

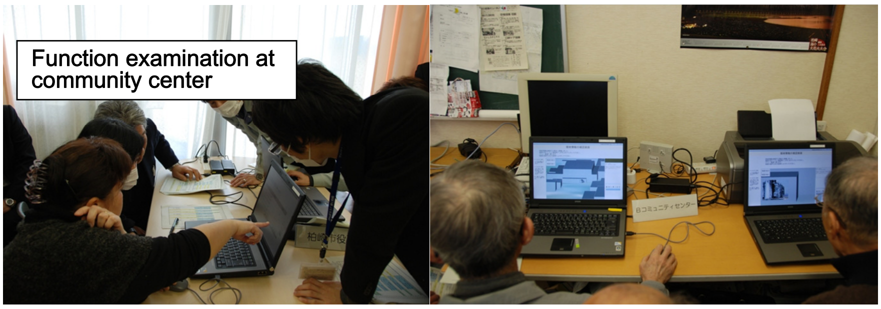

Figure 6. Functional verification tests of the system human interface

5. CONCLUSIONS

This study has proposed a framework for achieving effective risk communication concerning nuclear safety in the case of external events by cooperating with local communities. The contents of information for risk communication as well as measures for materializing and applying the technical basis of information system were also presented.

The Great East Japan Earthquake, tsunami, and Fukushima accident in 2011 have focused international attention on transparency and risk communication concerning nuclear safety. In France, the Nuclear Safety and Transparency Act was enacted in 2006. This Act provides a framework for smooth communication concerning risks pertaining to nuclear facilities among the national governments and local governments, regulatory agencies, operators, and residents.

International institutions such as the IAEA and OECD/NEA (Nuclear Energy Agency of Organisation for Economic Co-operation and Development) also have been proactively working to ensure the transparency of information concerning nuclear safety.

In Japan, revisions to the laws and regulations concerning nuclear safety are under discussion. When the details of information dissemination and risk communication are incorporated in the laws and regulations, it will be necessary to establish their technical basis and guidelines.

The framework and information system developed through this study will be a practical technical solution based on the lessons learned from the earthquake, tsunami, and Fukushima accident, and will surely contribute to better regulations in the future.

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