Establishing a Disaster Information System to Practically Support Disaster Countermeasures: Conducting and Reviewing Demonstration Experiment

by

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ABSTRACT

Although information systems are used in order to collect and share information at a time of disaster, such systems are not always effective. In this context, after analyzing the reasons for such ineffectiveness and current problems in disaster countermeasures, we established an information system as well as our disaster countermeasures business model that would be put into operation after introducing such an information system. Then, we also conducted a demonstration experiment in order to evaluate the practical usefulness and effectiveness of the information system and task model. Our experiment revealed that the information system would contribute to quickly collecting and sharing disaster information, but the operationality and operational rules require some improvements and modifications. After addressing these problems, the Chubu Regional Bureau will start full-scale operation of the system and business model. We also outlined these outcomes in the system's basic specifications and some other documents. These documents will contribute to mitigating system development costs if policymakers refer to them when they establish new disaster information systems in the future.
Keywords: Disaster information system, Gazetteer, Information Gathering & Sharing Platform, Interface among systems

1. BACKGROUND

Information systems are used in order to collect and share disaster information. However, such systems do not always bring about the intended outcomes in many cases because of inadequate or inappropriate reporting system and rules, which include the following problems: Operators doubly enter data in the existing systems; and staff still communicate over the phone or by fax even after implementing a new system.

To solve these problems, the Earthquake Disaster Prevention Division and the Information Technology Division, NILIM (National Institute for Land and Infrastructure Management), as well as the Information Access Division, GSI (Geographical Survey Institute) jointly began efforts in FY2003 to analyze potential problems that prevent effective operations of disaster information systems and identify proper solutions for these problems. As FY2005 is the last fiscal year for these efforts, we have been working with Chubu Regional Development Bureau since the beginning of FY2005 to improve the practical outcomes of setting up the joint review working group. On February 16, 2005, we conducted a demonstration experiment on the new disaster countermeasures, assuming that we would employ the new disaster information system derived from our research. Then, we evaluated the practicability and effectiveness of operating such a new system and business model derived from our research.

For more information on the detailed background of our research, research process and the business model, refer to the document listed as [1] in the references.

2. OUTLINE OF DEVELOPED DISASTER INFORMATION SYSTEM

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2.1 Examining Proper Functions of Such New System

Even if a new information system is installed, it does not always bring about the intended outcomes in some cases. This is partly because the existing disaster information system prevents user friendliness if the system has too many functional capabilities. In our research, we analyzed problems in collecting and sharing information by holding a hearing session with staffs in MLIT regional development bureau that have actually handled disaster countermeasures during major earthquakes in the past. Then, we identified the requirements for system functions by examining whether or not an information system would properly contribute to solving these problems and, if so, what kind of functional capabilities the information system should have.

2.1.1 Problems in Collecting and Sharing Information during a Disaster

We held a hearing session with MLIT regional development bureau staffs that actually handled disaster countermeasures during the Sanriku Minami Earthquake in May 2003, the Tokachi-oki Earthquake in September 2003, the Niigataken-Chuetsu Earthquake in October 2004 and some other earthquakes. We held this hearing sessions to identify actual countermeasures and problems. Among the hearing results, Table 1 shows the problems in collecting and sharing disaster information.

2.1.2 Necessary Functions for Solving Problems

When solving the problems listed in Table 1, the information system would make contributions from the following aspects.

(1) Collecting disaster information

From various systems, operators will be able to collect information useful for disaster countermeasures.

(2) Analyzing information

Operators will be able to analyze from various perspectives, paying attention to the information's roles in disaster countermeasures. Operators will be able to properly select and display the necessary information.

(3) Managing information

Operators will be able to manage information in terms of time and location. Operators will be able to easily categorize reported information.

(4) Distributing information

Operators will be able to view particular information at multiple organizations or departments at the same time. With a single data processing task, operators will be able to provide information to many stakeholders. (An increase in such stakeholders should not lead to heavier workload on data operators.)

From these viewpoints, the disaster information system should have the following functional capabilities.

(1) Requirement 1

By collaborating with information systems and database systems used under usual circumstances, operators will be able to search for and cite necessary information.

[Example 1] By associating damage information, and the affected facility's drawings with damage location or the affected facility's name as a key, operators will be able to quickly collect the necessary information.

[Example 2] By using a camera system to capture visual images of the site that are necessary for disaster countermeasures, the disaster information system will display a camera icon on its map. The system provides visual images captured with the camera system if a data operator clicks on the camera icon.

(2) Requirement 2

The information system should have "maps" and a "bulletin board" as its basic capabilities. Operators will be able to view necessary information according to each aspect of disaster countermeasures.

(3) Requirement 3

The disaster information system should manage "time" and "location" data, which are included in the reported information. For example, the disaster information system should be able to import temporal or location data from fax messages and store up these data in the system.

(4) Requirement 4

By using a web-based approach, multiple disaster countermeasure staff will be able to view the data on their browser at the same time.

For example, if an operator receives information from a local office and enters it in the system, staff at the MLIT regional development bureau and the MLIT headquarters will be able to view the data at the same time.

(5) Requirement 5

In order to reduce the data entry workload as much as possible, the information system should employ the current fax-based data transmission where possible, and minimize data entries. The system should also replace telephone communication because it is difficult to make a phone call during disaster countermeasures.

Newly developed disaster information system is characterized by the following four points show: (Fig.1)

(1) Platform for sharing disaster information

This platform electronically provides the same functions as the traditional maps and whiteboard, which are currently used for showing damage information at the disaster countermeasures headquarters. Fig.2 provides the outline of the electronic map, which electronically displays the territory map, as well as the electronic bulletin board, which electronically assumes the same roles as the whiteboard.

They have the following main functions.

[Electronic map]

i) It is able to display the map at a designated contraction scale. It is also able to designate map levels, such as overall areas that the MLIT regional development bureau or local offices are in charge of, or a prefecture-wide map. The system has six contraction scales, ranging from 1/300,000 to 1/2,500.

ii) As it employs an indirect location reference database (gazetteer), the system is able to search for an intended location by using a portion of the location name as a keyword, and it displays a list of intended location candidates. When an operator selects one of these locations, the system will display a map so that the selected location lies at its center.

[Electronic bulletin board]

i) The electronic bulletin board has three elements: the newest data portion on its top page, the list data screen and the detail data screen.

ii) The list data screen is able to sort data on a time-series basis, responsible local office basis or prefectural basis.

iii) The system is able to print out its input data in a designated list format. It is also able to export data to spreadsheet software and automatically generates a proper format reportable to higher organizations.

iv) It is difficult to identify newer information on the traditional fax sheets, because faxes arrive one after another. On the other hand, the information system provides easily viewable data because it displays a new data element in red.

v) An operator is able to easily confirm incoming data.

vi) When entering follow-up data, an operator needs only enter a new data element because the system automatically imports the previously-entered data from the previous report.

[Data link between Electronic map and electronic bulletin board]

The information system provides a data link between the electronic map and electronic bulletin board. If an operator selects a location on the map, the system displays data on the selected location. From the detail data screen that provides the detailed information on a certain location, an operator is able to view and confirm its location on the map.

(2) Interface among systems

If the existing system contains and manages information, our new system prevents double data entry because the system imports such data from the existing system. In our project, we developed a data exchange rule for intersystem data exchange (i.e., intersystem interface specifications). In our experiment, we actually used the new rule, collected applicable data from road closure database and specific systems that handle CCTV camera images, and displayed these data on the system screen.

(3) Indirect location reference database (gazetteer)

If an operator inputs location data of affected area by using mile posts that are currently used for managing rivers and roads, the new system converts it into longitude and latitude data, and displays such data on the map. When an operator inputs a distance mark in the new system, the operator is able to search for data related to such distance mark.

(4) FAX-OCR

Disaster countermeasures staff usually use drawings that show handwritten disaster damage information. On the other hand, when an operator sends a paper document via fax in the same manner as the traditional approach, the new system automatically imports the received data into its scanner, and electronically displays and manages the data, rather than printing out paper-based data.

3. OUTLINE AND OUTCOMES OF DEMONSTRATION EXPERIMENT

Applying the disaster information system and our system usage stated in Section 2 above, we conducted a demonstration experiment in order to evaluate the effectiveness and practicability of the disaster information system.

3.1 Purposes of Demonstration Experiment

The demonstration experiment has the following main purposes.

First, we intended to evaluate the outcomes of our research by actually operating our new system and business model under a certain disaster scenario.

As the first aspect in our evaluation process, we focused on evaluating the practicability of our developed system. This would reveal the practicability and feasibility of our new approaches, such as the FAX-OCR functions, as well as the new disaster countermeasures business model that incorporates the new information system. As the second aspect in our evaluation process, we focused on evaluating the effectiveness of our development efforts. In other words, we compared the new disaster countermeasures tasks with the new disaster information system installed and the traditional telephone- or fax-based approach. By doing so, we evaluated to what degree we could reduce the workload. Our evaluation revealed necessity of some improvements in the system, which would contribute to enhance the practicability of our new system.

Second, we intended to provide experiment participants with some information on the beneficial points of employing our new business model and information system.

3.2 Outline of Demonstration Experiment

(1) Demonstration experiment

i) Participants

The following participants took part in the experiment: Planning Department in charge of coordinating the overall tasks of the MLIT regional development bureau, the River Department in charge of managing river-related facilities, and the Road Department in charge of managing roads, as well as river offices and national road offices in charge of disaster countermeasures on site.

ii) Player levels

Our demonstration experiment has two player levels at departments in the MLIT regional bureau and participating local offices.

1) Data reader: Decision makers

They mainly check out input data and communicate with related departments/local offices.

2) Data operator: Data operators, such as staff in charge of entering system data

They mainly enter or coordinate data and prepare documents.

(2) Disaster and scenario assumed

i) Outline of assumed earthquake

- Date/time: Around 11:00 a.m., February 16, 2006
- Seismic center: In the waters off Tokaido
- Others: No aftershock assumed. Assumed that tsunami had arrived after the earthquake.

ii) Damages assumed

We assumed that some rivers and national roads would suffer damage resulting from the earthquake.

iii) Outline of scenario

Our scenario has two phases: Phase I and Phase II.

1) Phase I

Phase I starts with setting up a countermeasure framework and ends at initial inspection. Players entered and viewed inspection data. In Phase I, we finally confirmed how well the entire system would work and also evaluated how familiar data readers and data operators were with their own tasks.

2) Phase II
Phase II starts with when data operators would have entered inspection/damage data to some extent and ends at when they would start emergency recovering tasks. We handled disaster countermeasures by using our information system.

iv)How to assume disasters and scenario

1) We assumed certain disaster countermeasures tasks, which would bring about positive impacts on disaster countermeasures if our disaster information system were employed. (Table 2)

2) In addition, we also set up certain tasks so that we would be able to evaluate the performance of our new system capabilities and explicitly understand some positive impacts. In addition to our assumption as stated in 1) above, we also assumed some tasks that would explicitly bring about positive impacts on the system's functional capabilities.

(3) How to allocate tasks for players
We allocated player's tasks by distributing a (pink color) card that specifies the player's tasks. In the experiment, the controller basically did not orally specify the player's tasks over the phone. Fig.3 shows an example of the card specifying the player's tasks.

3.3 Experiment Results

When considering the experiment as whole, participants from MLIT regional development bureau staff that mainly acted as data readers in the experiment provided positive responses, stating that the new disaster information system was helpful in their tasks. Local office workers, who mainly acted as data operators, highly evaluated that the new system provided an easily viewable data screen, but they also pointed out many problems that would require improvements.
Positive responses are shown at 3.3.1 to 3.3.3

3.3.1 Overall Evaluation

- The new system is good because it only imposes a smaller amount of workload than the current system and also eliminates data input errors.
- It is highly user-friendly and provides significant positive impacts.

3.3.2 Supporting Capabilities in Collecting, Analyzing and Sharing Information
- It is good because the system provides the newest real-time information.
- It is possible to share information with many stakeholders.
- By using the system, it becomes easier to coordinate disaster-related data.
- It becomes easier to understand affected locations.

3.3.3 Impacts of Specific Functional Capabilities
- The indirect location reference database enables a map-based data search. With the new system, it becomes easier to collect data on a certain location (a specific mile post).
- FAX-OCR is effective if a local office has a poor network connection or if staff are unfamiliar with how to use a PC. It is good because a fax document is attached to the map (on the top of the screen).

Participants also indicated the following problems that require some improvements.
(1) In some cases, the system is difficult to operate or provides some confusing data screens.
[Examples]
i) The button names do not represent functional capabilities intuitively understandable.
ii) Icon marks are not intuitively understandable.
iii) Some improvements are necessary for switching over multiple screens, screen locations and screen sizes when there is more than one screen on the display. (Operator sometimes needs to find the screen he/she was working on, as another screen may appear on the top by some data process.)
(2) Some improvements are necessary to prevent data operator's errors.
[Examples]
i) Buttons should be properly located to prevent data operator's errors. (These buttons are

located close to one another, which could easily result in pushing the wrong button.)
ii) Updating the map is different from updating the bulletin board. (I had wrongfully thought that updating the map or bulletin board would automatically update both.)
(3) The system has way too many operation steps.
[Examples]
i) It is troublesome to confirm incoming data because I need to do it by opening the detail data screen. (It would be better if we could do that on the list.)
ii) As an decision maker, I have two different screens for inspection data and for damage data because I like to manage them separately. However, as a data-input operator, the system would be better if we could enter the inspection and damage data at the same time.
iii) Operators could easily select a wrong data entry screen and enter the wrong data. As the data screens look similar to one another, operators could easily make a mistake (e.g., damage data might be entered on the inspection data screen).
(4) It is necessary to have a function to ensure timely confirmation of new incoming data.
[Examples]
i) It is difficult to distinguish between already-read data and unread data.
ii) The system should have an alarm to let us know when new data arrive at the system.
(5) It is necessary to modify or supplement the current rules.
[Examples]
i) Each division should check out their data when sending or reporting their data. (A report from a local office to a regional bureau requires the approval of the head of the local office. However, a new approval rule is necessary in order to operate the new system in a better manner.)
ii) Report titles are not coherent. We don't have a proper rule on describing data even though this kind of rule is a must for proper data analysis.
(6) Others
i) It would be better if we could customize screen shots or functional capabilities for each user.
[Examples]
-Some data displays or functional capabilities are not necessary at the local office level. (It was necessary to select the necessary data at the local offices.)
-Two data categories (river and road) would be okay for the Planning Department, but the Road Department will need more detailed data categories of only road.
ii) Proper screen shot or expression is necessary
[Examples]
-The system would be better if it calculates some data so that we could answer routine questions from the MLIT headquarters. (For example, the system should be able to calculate the inspection progress percentage.)
iii) Some improvements are necessary in the indirect location reference database.
[Example]
-The system would be better if we could search an intended location by using the intersection name as a keyword.
iv) It is necessary to provide easily viewable maps.
[Examples]
-The system provides many unnecessary data displays. (It is possible to set the data items for dispaly, but the default data shot provides so many data items.)
- When we have an increased number of data showing on the screen, it is difficult to identify the selected data items.
v) Problems in FAX-OCR
[Examples]
-The system should have an alarm to let us know that the data have arrived.
-The data entries in OCR format should be fully optimized.
vi)The system should have more functional capabilities in the future.
[Examples]
-The system should automatically import data by using sensor-based systems.
-The system would be better if it imported data from GPS mobile phones.
-We need applications for our tasks under usual conditions.

We have been making efforts to solve the aforementioned problems after setting up our priorities.

4. FUTURE EFFORTS

After some modifications in line with our experiment outcomes, the Chubu Regional Development Bureau will start operating its new disaster information system in FY2006.
We also intend to develop a new operational manual and specifications after correcting some problems, paying attention to the results of our demonstration experiment (Fig4). The outcomes of our efforts will contribute to reducing R&D costs if they are effectively used for developing a new system or expanding the system functional capabilities.

5. REFERENCES

1. Kusakabe, T. and Sanada, A. : Application of Information & Communication System for Better Coordination among the Emergency Responders, *Proc .the 37th Joint Panel Meeting of U.S.- JAPAN Panel on Wind and Seismic Effects UJNR*, pp297-310, 2005

Table 1 Problem in Collecting and Sharing Disaster Information

Tasks	Current problems
Collecting information	1) The system does not provide visually apparent data. 2) We also need various data such as damages on facilities outside our responsible areas, but such data are very difficult to get. 3) It is difficult to effectively use our data available under normal conditions.
Analyzing information	4) Information will become deteriorated. Data processing is difficult. 5) Some redundant tasks are emerging.
Managing information	6) The system is difficult to manage data temporally or spatially. 7) Processing a massive amount of data is difficult.
Distributing information	8) Telephone line convergence emerges. 9) Inefficiencies, workload and artificial mistakes will increase because the staff need to provide multiple stakeholders with data. 10) Data communication channels have been designed, merely by paying attention to data management needs.

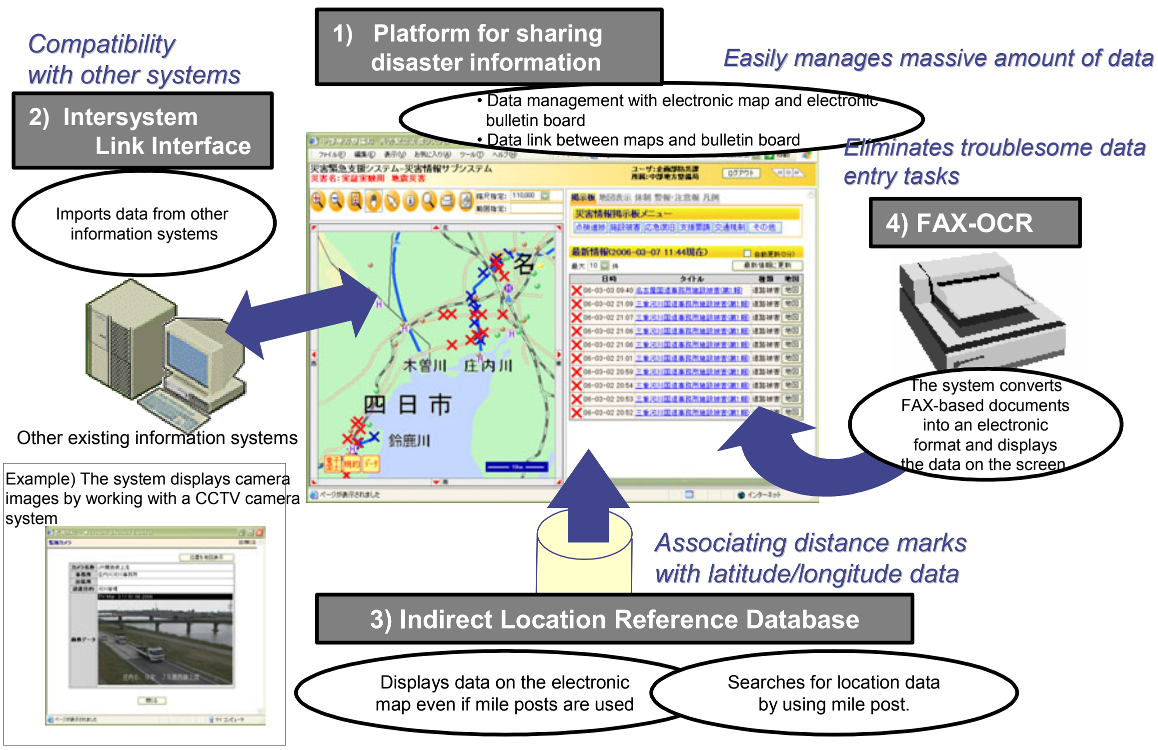
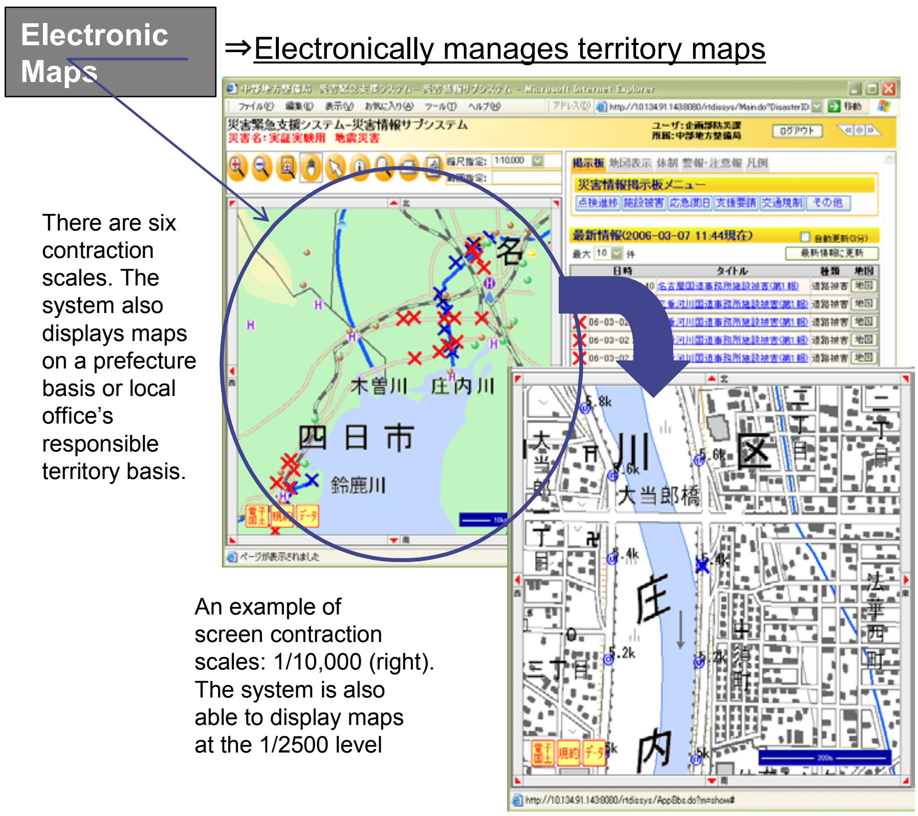
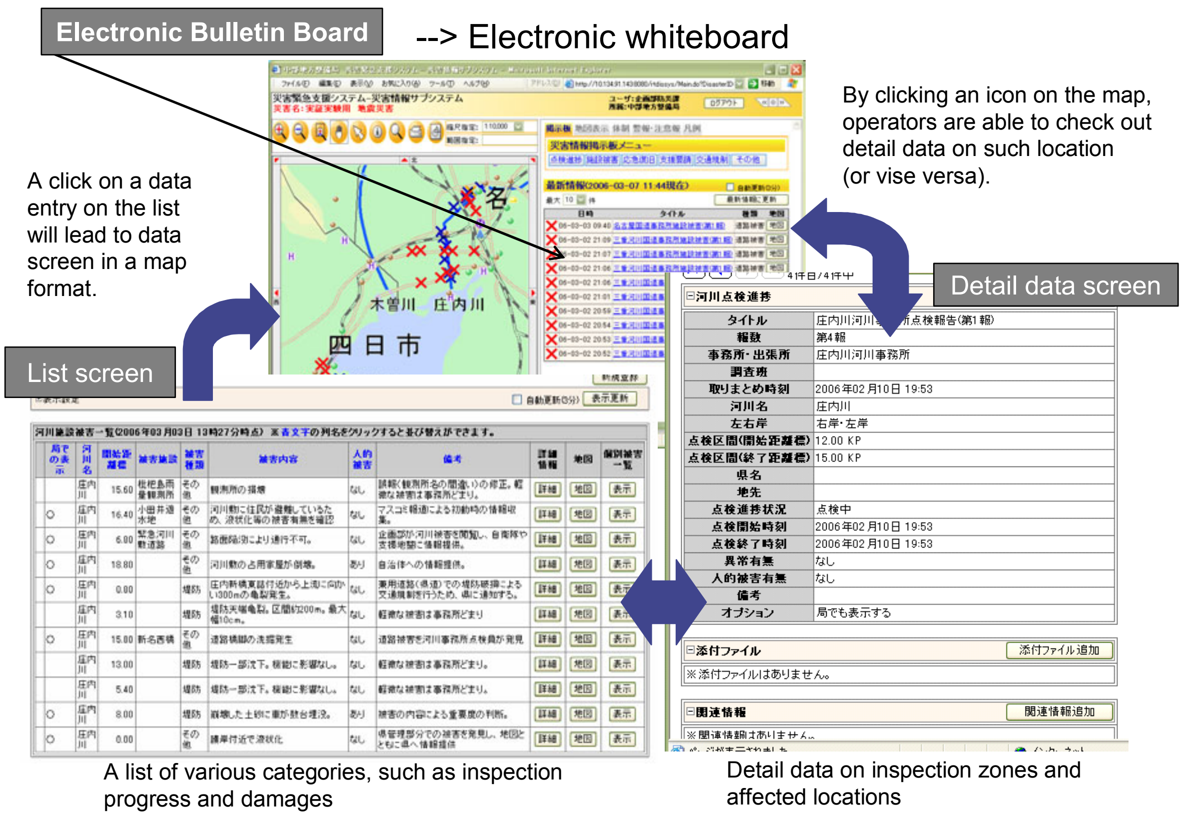


Fig.1 Main Characteristics of Disaster Information System in our Development and Demonstration Experiment Efforts



(1) Electronic maps



(2) Electronic Bulletin Board

Fig.2 Outline of Platform for Sharing Disaster Information

Table 2 Scenarios assumed (details)

Collecting information

[All staff are able to check out information once the data is entered in the system]

- Staff would answer questions from mass media, local governments and other organizations.
  - ◆ They would provide information (without making inquires to pertinent organizations) based on the data displayed on the system.
- River office staff would confirm detours.
  - ◆ They would provide information (without making inquires to pertinent organizations) based on the data displayed on the system.
- By using media information (residents evacuation to river area or tsunami residues accumulation at coastal areas) when little information is available, the staff would provide inspection-related instructions to check out these locations.
  - ◆ The system would provide data that have been difficult to use so far.

Analyzing information

[Easily manages information]

- Staff would answer questions from local governments about XXX River, Route XX or a certain location.
  - ◆ The system would identify the location in question from address data or distance marks and display the data relating to such location.
- Staff would coordinate data available as of XX o'clock and report them to senior officials and the Ministry headquarters.
  - ◆ They would coordinate the data entries (without transcribing or re-typing them).
  - ◆ The system would automatically sort out the data in the bureau's jurisdiction into a report format acceptable to the Ministry headquarters.
- Staff would answer questions from XX Prefecture about prefectural information, XXX River or National Route XX.
  - ◆ The system would display a map on a prefectural basis or local office's responsible territory basis.
  - ◆ The system would display a list of bulletin boards by using prefectural, river or route name.

[Others]

- We assumed serious damages, less serious damages and death of passengers or users.
  - ◆ Evaluates priority in sending data

Table 2 Scenarios assumed (details) (Continued)

Managing information

[Easily manages information]

- Road or river administrators would address the damages after receiving a report from residents. They would manage data, associating them with resident reports or actual disaster countermeasures.
    - ◆ The system would comprehensively manage related data in a category, such as unidentified data or administrator's confirmed data.
- Damages would occur at the same time at an embankment at adjacent distance marks.
    - ◆ The system would properly manage data by enlarging maps or displaying a bulletin board list even if multiple affected locations exist nearby.
- The system would easily convert data into an electronic format because it has FAX-OCR.
    - ◆ The system would manage data that are difficult to use so far.

[Real-time data and historical data on disaster countermeasures are available]

- Data operator would enter wrong damage data in the system and then correct them.
    - ◆ They would easily search for data entry (sorting out the data on a time-series basis, facility basis, or mile post basis).
    - ◆ The system would also display the data correction process. It is available to any staff at the site.
- As some other departments have provided disaster data, staff would instruct a local office to collect data on site and conduct subsequent countermeasures.
    - ◆ As the system would display actual disaster countermeasures at affected locations, system users would easily confirm actual countermeasures that are taken in line with their own instructions.

Distributing information

[Proper role sharing between information system and FAX/phone]

- River office staff would identify a road disaster.
    - ◆ They would report such damage, and they would be able to check out the data on the system (without making a phone call or sending a FAX).
- They would make the first report of damage over the phone and check out detailed data on the system.
    - ◆ Proper role sharing between the phone call and the information system
- Staff would state necessary equipment over the phone and enter equipment data in the system for the purpose of data management.
    - ◆ Proper role sharing between the phone call and the information system

Role instruction card			
To:	Data readers at Shonai River Office	Reference #	Sho-etsu 14-6
From:	-	Time of delivering the card:	14:50
Re:	Inquiries from the police department		

The police department has made inquires about the 8-8.2km slope collapse on the right bank. Output the map data and provide the data via fax in the following manner.

Operational procedures

1) Display a list of river facility damages ("Shonaigawa River Serious damages") by selecting Bulletin board - Disaster Information Bulletin Board Menu - Facilities Disaster-River

If the system has already displayed the river facility damages on the screen, the user should use the same screen.

2) Click the “Map” button on the data window of the damage at the 8-8.2km on the right bank to display the map of the affected location.

Sometimes, you might face difficulty in identifying proper data because the list provides too much information. In this case, select “Shonai River Office” by switching over the list.

3) The system will update the map display data so that the affected location lies at the center of the map.
4) Select 1:10,000 from the Contraction Scale pull down menu of the map screen.
5) The system will update the map’s contraction scale. Click the “Print” button on top of the map screen.
6) Print out the map from the printer.
7) Follow the procedures stated above to print out the map at the contraction scale of 1:5,000.

8) Write down the affected location name (river name, right/left bank or distance mark) on the report form, and then place it and the map(s) in the FAX transmission box.

9) Click the Detail button on the river facility damage list in order to open the detail data on such damage.

10) Record the fact that you provided the data to the police department. Enter and store the data in the following manner.

Titles filled in by data operator	Player's name
Description	Providing affected location’s map data to the police department via fax.

> Provides instructions on data entry or data screen tasks.
> Some data operators might provide itemized instructions, while other operators might provide their instruction written in a colloquial style.
> In the case of the latter, staff need to find out necessary information from the context and enter or display the data on the system.

Purpose of allocating roles	System functional capabilities ・Displaying and printing out the map data System operation ・Providing data for other organization(s)

> This section describes what you would like to evaluate by allocating player roles (e.g., evaluating system's operationality or efficiency improvement)

If you have any comment on data system operation, please write it down in the margin on this format.

Related topic(s)	

> Fill in this section if you have any additional comments, such as the Nth report.

Fig 3 Sample of Card to Specify Players’ Task

[Studied contents]	[Final Results]
Disaster countermeasures task model	Use case chart
	Disaster countermeasures manual
System basic specifications	Standard specifications
Data dictionaries	JPGI-compatible standard specifications
System interface specifications	Standard specifications (draft)
FAX-OCR	Project book, functional specifications, user manual
Indirect location reference database	Project book, functional specifications, user manual

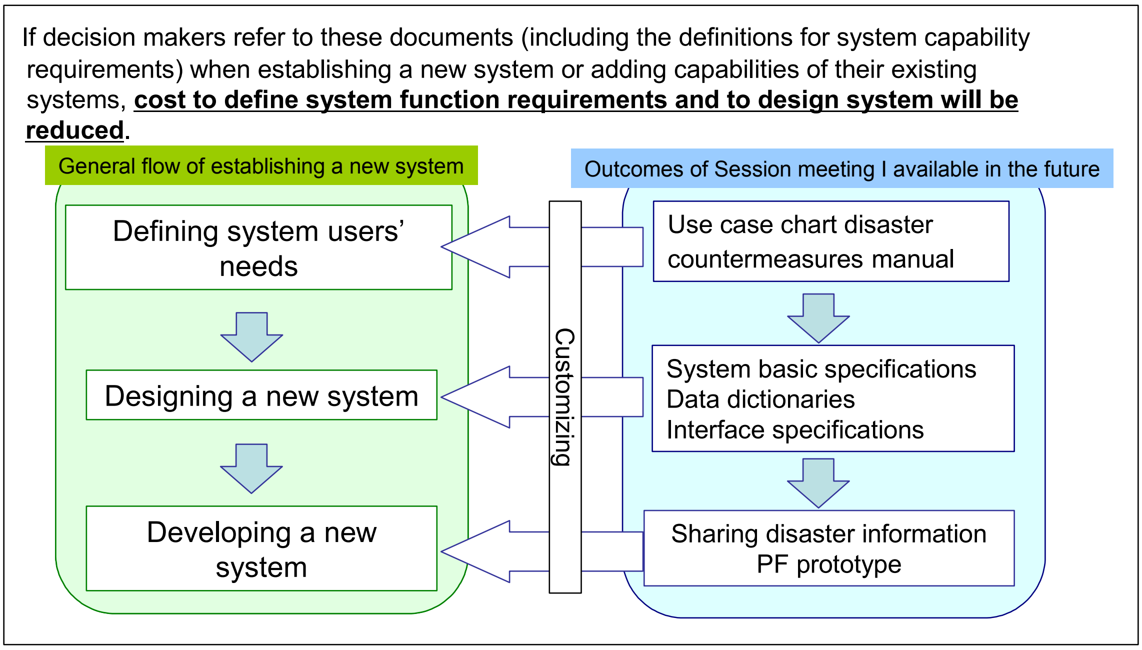


Fig 4 Final Result and Its Contribution in Developing New Disaster Information System