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Flexible Action Management on Real-time Disaster Response

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Abstract

Real-time disaster response requires cooperative works between emergency headquarters and disaster sites with a huge amount of information under various situations. We proposed that we need Flexible Action Management (FAM) on real-time disaster response. FAM aims for partially flexible but totally controlled secure actions.
We launched a research project, called Red Rescue Project aiming to utilize small-capacity broadcasting data for FAM on real-time disaster response. In this paper, we suggested the concept and the goal of the project using system design management methods. Also we reported the key results from the project such as the implementation ideas of small-capacity messages and prototyping experiments on Indoor Messaging System environment with 3D data. We could demonstrate the feasibility of utilizing small-capacity data for FAM on real-time disaster response.
Keywords: disaster response; action management; Indoor Messaging System

Introduction

As systems are getting larger and complex in recent years, the amount of information is getting astronomical. Information aggregation systems like GIS (Geographical Information System) are useful for information sharing, but real-time decision making and cooperative work are not sufficiently supported by computer systems. For example, real-time disaster response requires cooperative works between emergency headquarters and disaster sites with a huge amount of information. People need to collect the disaster information and have to make decisions for safety actions depending on their situations. However, situations are spatially and temporally different from each other, so people need to act flexibly according to their situations. In this point, emergency headquarters need some communication methods for Flexible Action Management (FAM). Because people do not always take appropriate actions flexibly, they might cause secondary disasters including security issues. FAM aims for partially flexible but totally controlled secure actions. This concept is related to Collective Systems study area described in (Namatame 2006).
While cooperative works are conducted between emergency headquarters and disaster sites, the information they need are different because of the differences of their roles and situations. Emergency headquarters need panoramic view and macro information of the disaster to minimize the damage. On the other hand, disaster sites need specific view and micro information for their own safety

measures. We have studied this cooperative work model on Asymmetric Information Environment (AIE) and found the followings.
- Using small data like positioning information and status information of agents, we can visualize the situations and take effective actions for cooperative works on AIE, documented in (Kusuda and Ogi 2009).
- Communication techniques on AIE such as signalling, positioning information monitoring and positioning information screening are effective for geospatial analysis of cooperative works on AIE. Because they can create information flows to create actions. We have to select the techniques according to the case, documented in (Kusuda and Ogi 2010).

These findings suggest that even using small data we can conduct FAM. Also FAM is needed on AIE because FAM prevents from secondary disasters derive from selfish activities like morale hazard based on AIE.

Following these researches, we launched an experimental project, called Red Rescue Project. In this project we aim to utilize small-capacity broadcasting data for FAM on real-time disaster response. Our target media is QZS (Quasi-Zenith Satellite), the first Japanese positioning satellite, which will be launched in summer of 2010. The reasons why we selected the satellite are the followings.
- Satellite technologies are resistant to disasters.
- QZS has L1-SAIF signal that carries small-capacity broadcasting data.
- As QZS is a positioning satellite and compatible with GPS (Global Positioning System), we can utilize positioning information for rescue activities with widespread GPS terminals.

In this paper, we introduced the concept and the goal of the project using system design management methods described in (Kohtake et al. 2010). Also we reported the key results from the project such as the implementation ideas of small-capacity messages and the prototyping experiments on Indoor Messaging System environment with 3D data.

Red Rescue Project

Red Rescue Project is a 3-year research project funded by MEXT (Ministry of Education, Culture, Sports, Science and Technology) since 2009. The project name derives from "REal-time Disaster REsponse using Small-Capacity data from the UniversE." We aim to utilize small-capacity data from satellites for FAM using Satellite Based Augmentation System (SBAS) function.

Project Architecture. The project has five layers of research views including Application, Environment, Content, Process and Social systems. They are shown in Figure 1.

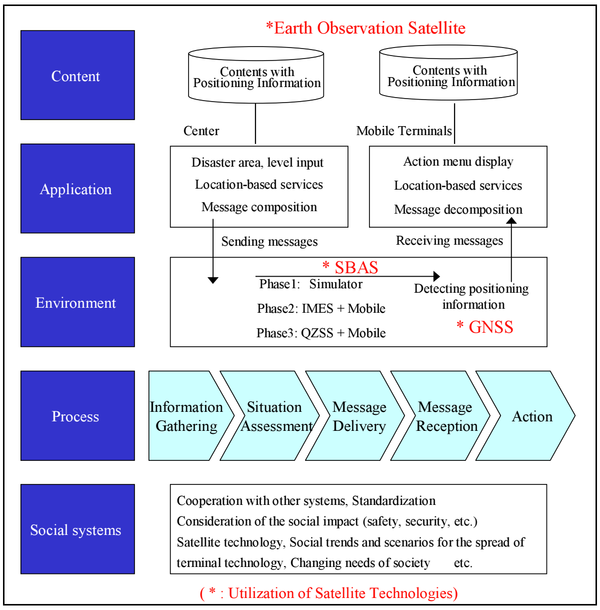


Figure 1. Red Rescue Project Architecture.

(1)Application. To realize FAM, the followings are to be developed. We have developed the prototype application systems.
- Location-based Services that use contents with positioning information

- Selective Message Delivery System with context-sensitive mechanism using disaster areas and levels information at emergency headquarters
- Flexible Action Menu Display System at receivers that induces appropriate responses to the disaster

(2)Environment. We planned 3 phases of experiments on the following environments.
Phase1: Simulator experiment on PC
Phase2: Indoor Messaging System (IMES) and mobile terminals environment
Phase3: Quasi-Zenith Satellite System (QZSS) and mobile terminals environment
We have finished Phase1 and Phase2 at the moment.

(3)Content. Location-based contents such as hazard maps and evacuation route maps are needed at disasters. Distributed contents management is important factor for FAM because users are not always connected to the networks at disasters. We developed 3D navigation contents for the experiment.

(4)Process. Disaster management process is important as a sequential view of real-time disaster response. FAM depends on how we can imagine the disaster and prepare for the disaster. (Meguro 2008) described that the improvement of "Disaster Imagination" capacity is the most important issues. We analyzed action scenarios at disasters and developed scenarios and action menus for the experiment.

(5)Social systems. With the external panel in the project, we discuss and study sustainable social system design such as interoperability, standardization, security, social trends and technology trends. We organized regular meetings with experts of Disaster Response Application team for QZS at Satellite Positioning Research and Application Center (SPAC).

Project Flow Chart. We introduced system design management methods to the project. Figure 2 shows the project flow chart. Using the methods we could make the project goal clear and promote the collaboration among the project members more easily.

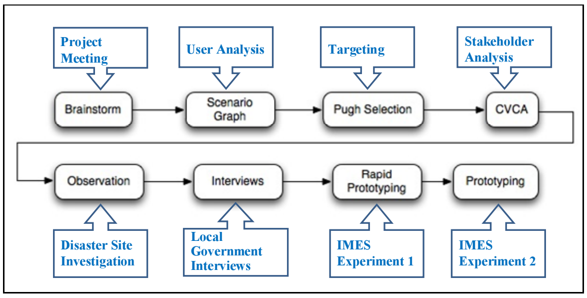


Figure 2. Red Rescue Project Flow Chart.

(1)Brainstorm and Scenario Graph. Scenario Graph is a method for clarifying the system requirements from the view point of the end users. In this phase we expanded the ideas and increased the flexibility. We organized brainstorming sessions and chose the scenarios in Figure 3.

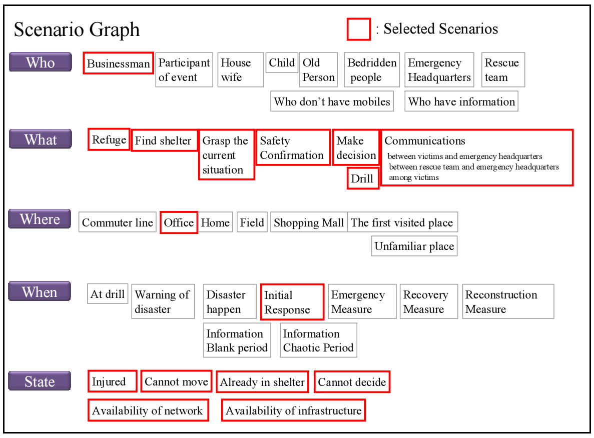


Figure 3. Scenario Graph.

(2)Pugh Selection. Figure 4 shows Pugh Selection. With this method we can focus on the most promising scenario. We paid attention to "When" part and compared the scenarios with the criteria and selected "Initial

Response" phase for this part. We found that Red Rescue solution is the most effective at the Initial Phase of disaster response. We also selected "Who" part and "Where" part as "Businessman" and "Office" respectably because the experiment was taken place in IMES environment. About the other parts, "What" and "State", we selected all the items to make the experiment scenarios realistic. Especially, "State" part is added later for making the disaster imagination more realistic. After all the processes, we selected the bold square parts in Figure 3. Using this scenario graph, we finally got the scenarios for IMES Experiment as Figure 5.

Scenario Selection: Pugh

＋ : Superior　S : Same　－ : Inferior

Criteria	Scenarios					
	hours～ Before the disaster	0～10minutes Disaster happen	～hours Initial Response	～days Emergency Measure	～months Recovery Measure	～years Reconstruction Measure
Alternative means	-	DATUM	S	S	- (Newspaper･TV)	- (Newspaper･TV)
(L1-SAIF) Necessity	+		+	S	-	-
Number of users	+		+	S (less necessary but longer time span)	-	-
Amount and variety of information	+		+	+	+	-

Figure 4. Pugh Selection.

Scenario1: Disaster → Grasp the current situation
→ Find shelter
→ Refuge

Scenario2: Disaster → Grasp the current situation
→ Try to Refuge
→ Find a hazard
→ Report to Emergency Headquarters
→ Refuge → Share the hazard info

Scenario3: Disaster → Injured and cannot move
→ Safety Confirmation and Request Rescue
Rescue Team
→ Wait → Plan the Rescue Route using the hazard info
→ Rescued → Rescue

Scenario4: Disaster → Already in safe area
→ Stay and Grasp the current situation
→ Safety Confirmation

Figure 5. Scenarios for IMES Experiment.

(3)CVCA. CVCA (Customer Value Chain Analysis) provides the view points of stakeholders and business model. Figure 6 shows CVCA of Red Rescue Project. We can consider not only end users but also all the stakeholders in the system.

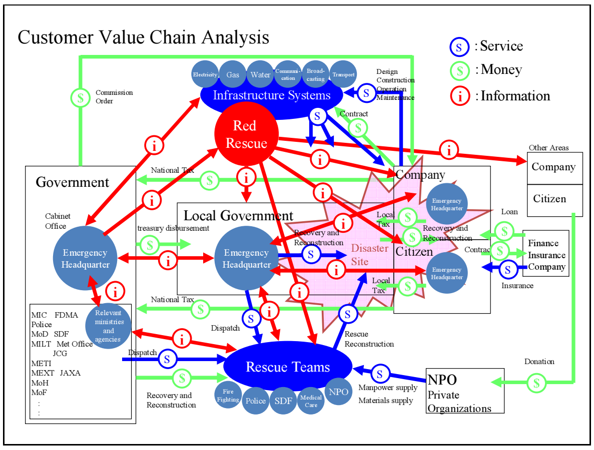


Figure 6. Red Rescue Project CVCA.

(4)Observation and Interviews. We had three surveys to visit local governments who had large natural disasters recently. Table 1 shows the results of the interviews. These comments will be discussed at the later part.

Table 1: Local Government Interviews

Local Government / Disasters	Interview Comments
A / Sediment disaster	(A1) Organizing information is a critical issue. Information is abundant but veteran staffs who can aware the significance of the information are less than before. Information organizing group and information analysis group are separately needed. (A2) Ideas for solutions: (1) Location-based photo organizing system (2) Area-specified evacuation instruction delivery system (3) Emergency navi-system for local government staffs using GPS (A3) Aerial photography is necessary for the initial response.
B / Heavy rain and flood	(B1) Evacuation instructions have limited effect. We need information delivery system for supporting the victims' own decision making. (B2) People unfamiliar with the locality got affected. (People who recently moved in, cars came down from the highway etc.) (B3) Power outages are caused by the flood. Waterproof mobile phones are useful. SOS mobile phones might be a good idea.
C / Earthquake	(C1) There is a problem of fast and accurate on information delivery. Even in shelters, official announcements are not understood properly. Confusion arose from the lack of uniform communications. (C2) The infrastructure only for emergency is not affordable. Area one-segment broadcasting has been proposed. (C3) "Prevent secondary disasters" is our safety slogan. Making simple manuals helps quick actions for disaster response.

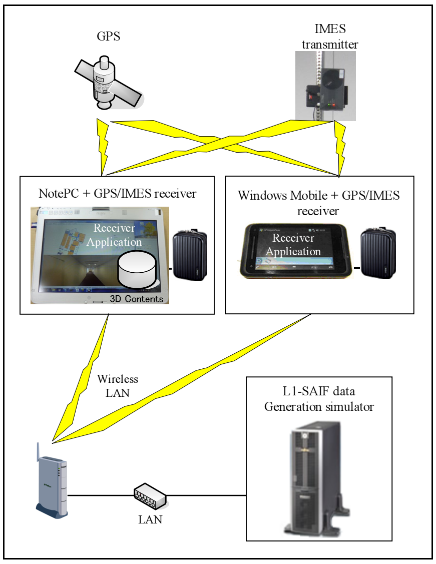


Figure 7. IMES Experiment System Structure.

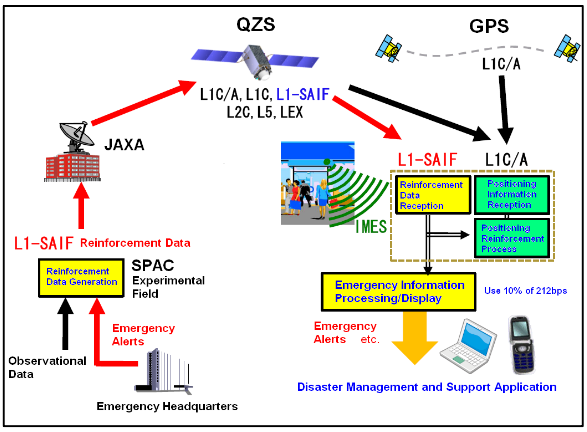
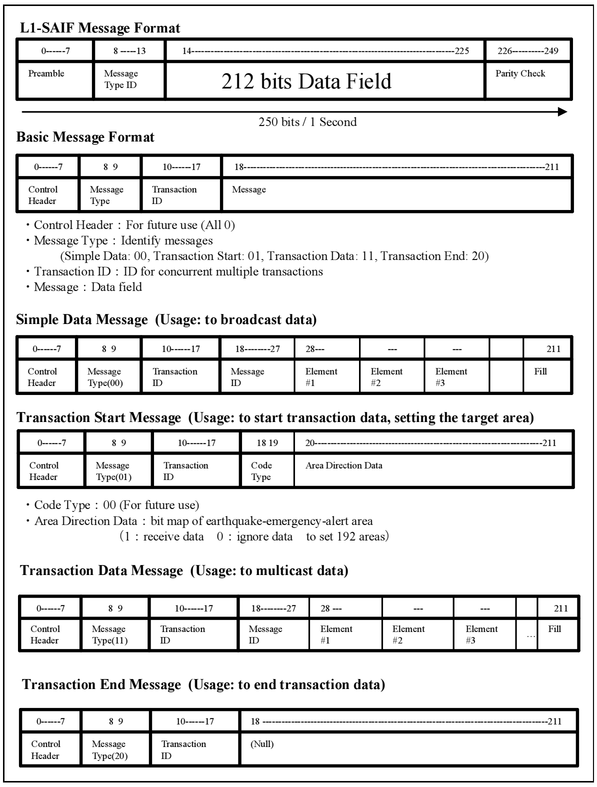


Figure 8. QZSS Experiment System Structure.

(5)Rapid Prototyping and Prototyping. Figure 7 shows IMES Experiment System Structure. We had IMES Experiments twice at Keio University. Figure 8 shows QZSS Experiment System Structure to be provided by (SPAC 2009). Figure 9 is L1-SAIF message format and our ideas of the message implementation. We developed the prototype system and tested on PC (Phase1) and on IMES environment (Phase2). As a result, we could demonstrate the feasibility of utilizing small-capacity data for FAM on real-time disaster response. Figure 10 is Action Menus. We can use some applications, such as escape route 3D navigator, safety confirmation tool, and information aggregation tools. Figure 11 shows 3D Navigation Contents and Application.



L1-SAIF Message Format

0------7	8 ----13	14--------225	226---------249
Preamble	Message Type ID	212 bits Data Field	Parity Check

250 bits / 1 Second

Basic Message Format

0------7	8 9	10------17	18--------211
Control Header	Message Type	Transaction ID	Message

・Control Header：For future use (All 0)
・Message Type：Identify messages
(Simple Data: 00, Transaction Start: 01, Transaction Data: 11, Transaction End: 20)
・Transaction ID：ID for concurrent multiple transactions
・Message：Data field

Simple Data Message (Usage: to broadcast data)

0------7	8 9	10------17	18--------27	28---	---	---		211
Control Header	Message Type(00)	Transaction ID	Message ID	Element #1	Element #2	Element #3		Fill

Transaction Start Message (Usage: to start transaction data, setting the target area)

0------7	8 9	10------17	18 19	20--------211
Control Header	Message Type(01)	Transaction ID	Code Type	Area Direction Data

・Code Type：00 (For future use)
・Area Direction Data：bit map of earthquake-emergency-alert area
（1：receive data 0：ignore data to set 192 areas）

Transaction Data Message (Usage: to multicast data)

0------7	8 9	10------17	18--------27	28 ---	---	---		211
Control Header	Message Type(11)	Transaction ID	Message ID	Element #1	Element #2	Element #3	…	Fill

Transaction End Message (Usage: to end transaction data)

0------7	8 9	10------17	18 --------211
Control Header	Message Type(20)	Transaction ID	(Null)

Figure 9. Message Implementation Ideas.

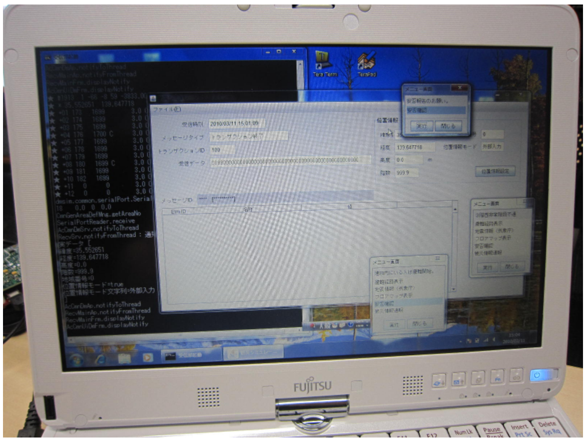


Figure 10. Action Menus at Receivers.

Figure 11. 3D Navigation Contents and Application.

Discussion

To build FAM solutions for real-time disaster response using small-capacity broadcasting data, we have launched Red Rescue Project and conducted system design management activities, implementation, tests and IMES environment experiments.

Feedback on interviews. As can be seen in Table 1, we have got many ideas for the project.

(1)Needs of FAM. Comments: (A-1), (B-1), (B-2), (C-1), (C-3).
These comments are related to the user needs for FAM. We noticed the followings.
- The main role of information delivery is to give awareness for effective actions.
- As life-threatening disasters are happening locally, context-sensitive decisions are needed.
- Not recognizing the differences between normal times and emergencies, navigation system does not help.
- Disaster response at information chaos period is needed. Multicasting communication method is effective for organizing information.
- To provide action menus to the victims is an effective solution for producing control mechanism against the chaos.

Lack of information, lack of experiences or knowledge, lack of awareness and lack of communications would cause secondary disasters. These issues are not only caused by natural disasters but also caused by human activities related with security issues. Red Rescue solutions should respond to these needs by flexible action menus.

(2)Ideas for solutions. Comments: (A-2), (A-3), (B-3). We noticed the followings.
- Automatic information processing using location information is promising.
- A picture is worth a thousand words. The use of picture and video information is effective way in inducing actions for disaster response.
- Easy user interface is required.

Automatic information processing, use of location information, use of rich contents as pictures, videos and aerial photos, simple and robust user interface are suggested. The direction of improvement is almost identical.

(3)Business model consideration. Comments: (C-2).
As is seen in Figure 6 (CVCA), business models for disaster related systems should be considered including everyday use of the systems. Dual use is preferable for cost saving. Emergency use of L1-SAIF signal seems to be a reasonable solution because the signal's main purpose is for positioning reinforcement.

Implementation Ideas. In this study, we assumed to use one of QZS's signal, L1-SAIF, 250bit/s as small-capacity broadcasting data. Our ideas on how to use small-capacity broadcasting data for real-time disaster response are the followings. We have already implemented them into the prototype system.

(1)Element method. To express flexible messages with small-capacity data, we introduced Element method as a data compression scheme. In this method, we use shared master data and send only parameters as elements. We defined eleven kinds of element data formats. Master data should be defined and shared before the communications but most of the emergency alert messages are typical, so this form-filling method is effective for emergency alerting purpose. One of the issues we have to consider further is the maintenance scheme of the master data.

(2)Bit-map method. As another data compression scheme, we developed bit-map method. In this method, we defined identifiers of receivers as a bit-map code. In this experiment, we used earthquake area information which defines 187 areas of all over Japan. To define the identifiers of receivers, at first we have to classify all the receivers and next we make a bit map of them and share it with all the receivers. We could make selective data delivery by using the bit map as Area Direction Data in Transaction Start Message.

(3)Transaction method. By using multiplexed data transactions, we could selectively receive messages, or mix multiple types of messages. There are three message types for Transaction Messages (Start, Data and End) as shown in Figure 10.

(4)Flexible Action Menu Display System. Taking flexible actions depending on situations, users have to know what the right action is. This system implemented the solutions for suggesting the appropriate action menus to the receivers using location information and alert messages. Using the action menus as shown in Figure 11, we could use some applications, such as escape route 3D navigator, safety confirmation tool, and information search tools. We need simpler and easier user interface.

Further simulation test. We studied the press documents of "The Iwate-Miyagi Nairiku Earthquake in 2008" and found that there are only 8 kinds of alert information. We tried to send the alert information by our method. 11 messages were tested and found that we could send key information. However, supposing to use a narrow band link such as 250bit/s in every 10 seconds, when data amount to be sent by element data is large, it takes time uselessly. In our test case, only one message out of 11 messages was this kind of data that was the detail seismic information of all over Japan. It took four minutes to send all the data. To improve the solution, we need to consider multi-level bit-map scheme to define receivers' groups.

Conclusions

We proposed that we need Flexible Action Management (FAM) on real-time disaster response. There are two reasons. At first, real-time disaster response needs flexible actions depending on situations. Secondly, real-time disaster response needs to avoid secondary disasters caused by security issues like miscommunications. FAM aims for partially flexible but totally controlled secure actions.

We launched Red Rescue Project and researched user needs of FAM and system requirements by system design management methods.

We could demonstrate the feasibility of utilizing small-capacity data for FAM on real-time disaster response.

The next step is to combine user requirements with the solutions on QZSS environment.

Acknowledgments

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References

Kohtake, N., Maeno, T., Nishimura, H., Ohkami, Y., "Graduate Program in Multi-Disciplinary System Design and Management." 20th INCOSE International Symposium, To Appear, July, 2010.

Kusuda, T., "Development Plan of Real-time Disaster Management Support Application with QZS. " The first Asia Oceania Regional Workshop on GNSS, Bangkok, January, 2010

Kusuda, T. and Ogi, T., "A study of positioning information utilization on real-time network systems for safety measures (in Japanese). " IEICE technical report, vol.109(250), pp.17--20, October, 2009

Kusuda, T. and Ogi, T., "Geospatial Analysis of Cooperative Works on Asymmetric Information Environment." ICCSA 2010, Part IV, LNCS 6019, pp. 336–345, Springer-Verlag Berlin Heidelberg 2010

Meguro, K., "Promotion of Seismic Retrofitting for Existing Low Earthquake Resistant Structures: The Most Important Issue for Earthquake Disaster Reduction." Vulnerable Cities: Realities, Innovations and Strategies, pp. 29-74, Springer Japan, 2008

Namatame, A., "Adaptation and Evolution in Collective Systems." World Scientific Pub Co. Pte. Ltd., Singapore, 2006

SPAC, "Disaster Response Application Experimental Plan for QZS (in Japanese). " http://www.eiseisokui.or.jp/ja/pdf/forum_06/forum_06-09.pdf, November, 2009

Biography

Tetsuya KUSUDA is a system engineer, Senior Manager at NTT DATA and a doctoral student of Graduate School of System Design and Management, Keio University. He graduated from The University of Tokyo and has Bachelor of Engineering degree in Mechanical Engineering in 1988. He is the project leader of Red Rescue Project and the team leader of Disaster Response Application team for QZS at Satellite Positioning Research and Application Center (SPAC).

Munetaka KIMURA is a computer system engineer, Senior Expert at NTTDATA. He is working for designing national geospatial data sharing network and disaster management system sent via QZS satellite to be launched in 2010. He is a graduate at International Christian University in 1996 and has Bachelor of Arts degree in Linguistics. His main interest is in GIS, user interface and computer security.

Naohiko KOHTAKE is an Associate Professor and current director of Aerospace and Intelligent Systems Laboratory at Keio University where he is responsible for space system engineering and intelligent systems. He has worked in research and development on avionics systems for the H-IIA rocket at Japan Aerospace Exploration Agency (JAXA), ubiquitous computing systems at Keio University, and on-board software at European Space Agency. He was a visiting researcher of user interfaces at Sony Computer Science Laboratories and an associated senior engineer at Digital Innovation Center in JAXA working on software independent verification and validation for satellites and the international space station.

Tetsuro OGI is a Professor at Graduate School of System Design and Management, Keio University. He graduated from the School of Engineering, The University of Tokyo and has Ph.D degree in Mechanical Engineering in 1994. His research interests include visual simulation, human computer interaction, virtual reality, and high presence communication technologies.