# Securing Communication Channels in Severe Disaster Situations – Lessons from a Japanese Earthquake

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**ABSTRACT**

Information delivery and sharing are vital for survival during and following a disaster. Information and communication technology (ICT) is supposed to support these processes effectively. To promote information delivery and sharing, the primary actors in charge of conducting a disaster relief operation at all levels of government have invested in developing a supposedly disaster-proof communication channel to be used exclusively when catastrophes hit. In 2011, the biggest earthquake on record hit Japan. ICT services were suspended because of a huge tsunami. This made it impossible for officials to respond as per the existing disaster management plan. The plan turned out not to be useful in response to such an unexpected event. This paper shows how municipal governments responded to the disaster and leads us to propose that unpredictable, large-scale disasters need communication systems that are founded in familiar contexts rather than technological complexity.

**Keywords**

Bricolage, communication channel, design theory approach, familiarity, municipal government.

## WATER, FOOD, AND INFORMATION

What would be the most important thing if you were the victim of a natural disaster? Needless to say, securing access to life-supporting essentials such as water and basic foods should come first. Then, what would be the next priority? Surely, it is information. A huge quantity of information flows through our everyday lives, even if we do not realize it. It is information technology these days that gives us access to most of this information. We rely greatly on it. Consequently, in the event of electric power being suspended, or information and communication technology (ICT) being destroyed by an unexpected catastrophic event, we might very well find ourselves isolated from the rest of the world.

The present research is based on the context of a huge earthquake, known as the Great East Japan Earthquake, which occurred in March 2011. The principal purpose of this paper is to provide answers as to how to help prepare for potential disasters of this magnitude through effective use of ICT in information collection and provision. The need to make a fresh start in this direction stems from the recognition that people in devastated areas may well be totally isolated from the outside world due to the complete and unexpected failure of ICT.

According to the literature on disaster management, the foremost response to a disaster comes from local organizations. (Drabek 1985). “Local” may refer to government, or voluntary and private organizations, but it is local government which owns “the first line of official public responsibility (McLoughlin 1985).” That is certainly the case in Japan, where municipal governments are predominantly in charge of running disaster relief operations. This paper, then, focuses on how municipal governments should secure communication channels to their residents in a severe calamity.

Within the administrative structure of the Japanese government, municipalities occupy the third rung. National Government occupies the top tier, followed by prefectural governments (47 of them) and municipal governments (1,742 cities, towns and villages as of January 1, 2014). The size of municipal governments varies enormously. Big cities such as Osaka and Yokohama each have a few million residents. Small villages have less than a thousand. There are several types of municipal governments, such as cities (requiring a population of over 50K), towns (variously defined in prefectures), and villages and special wards. Legally, the function of these governments is to provide a variety of services to their citizens but above all they have the obligation to maintain resident information, i.e., the data that serves as the foundation for government. Prefectures, on the other hand, are defined more loosely as wide area government.

Both prefectural and municipal governments conduct disaster relief operations such as helping disaster victims, securing the lives and safety of their residents, and supporting the recovery of local business activities. Commonly these duties are defined in the local disaster management plan. In addition, prefectural and municipal governments are expected to function as command centers for various support activities undertaken by the Self-Defense Forces, the Red Cross, and other public and private organizations.

Provision of information during a disaster is one of the important duties with which municipalities are charged. However, following the earthquake of 2011, residents were generally troubled by the level of information access to local actors and officials related to the relief operation. A Japanese private survey company conducted a survey in April 2011, which shows that almost 60 percent of evacuees at evacuation centers were dissatisfied with the process of getting information.[1] Anxiety caused by the many disaster-related problems was in no way alleviated. Municipalities clearly struggled to secure communication channels exactly at the time when broad availability of information was critically needed.

The research question posed in this paper is how to design a communication channel for municipalities that ensures stable provision of information to their residents. The Japanese government has dedicated huge funds to the development of a disaster-proof channel, which it believes to be fully effective once a disaster happens. The basic question is, however, whether this type of channel would really work in an unexpected disaster. We believe there is a need for new design principles in building information systems (IS) that are able to respond to a large-scale disaster. While our research applies an IS design theory approach (Brohman et al. 2009; Walls et al. 1992) which is quite similar to design science methodology, it aims to derive design requirements and systems features from practical observations. Theory connects the natural and the social world, and that connection is significant in guiding IS design (Gregor 2006).

This paper presents the following discussions: (1) what municipalities had assumed appropriate in the event of a disaster - the disaster management plan, (2) what actually happened in the field - a case study based on the Great East Japan Earthquake, (3) what information channel was actually used during disasters - results of surveys on Japanese earthquakes and heavy rain disasters, (4) the development of IS design principles, and (5) conclusion.

## MUNICIPAL DISASTER MANGEMENT PLAN

The Japanese public disaster management plan is normally based on two steps.

The first step, from a broad perspective of disaster prevention, mandates that each municipality draw up its local disaster prevention plan. In general, then, this plan specifies the scope of action to be taken by any relevant organization during a disaster, such as setting up a disaster response headquarters and confirming the safety of residents. Some plans also clarify the role of each operational division. After the disaster response headquarters is set up, many of the municipalities dispatch personnel for tasks such as operating the evacuation centers and transporting goods under instructions from those headquarters. This plan also provides guidelines on how to equip facilities and store relief supplies, how to raise resources which are required to conduct disaster relief operations, how to educate residents or conduct disaster drills with them, how to collect and provide information

[1] Last accessed Nov.10th 2014, at http://www.surece.co.jp/src/research/area/pdf/20110311_miyagi.pdf

related to the management of disasters, and so on.

The focus of this plan is to prevent devastating damage and reduce risks during a disaster. Furthermore, it is to make people, facilities and organizations robust.

To provide residents with access to information, the national government has allocated a large budget to developing channels of communication such as external public announcement systems and internal receivers, and an emergency alert system. According to an annual budget report by the Ministry of Internal Affairs, over two billion US dollars were spent in 2013 and 2014 to promote these ongoing projects.

The second step involves drawing up a business continuity plan (BCP). BCPs seek to eliminate or reduce the potential impact of a disaster before that condition occurs (Cerullo et al. 2004). As society becomes more and more dependent on its information technology infrastructure, the risks of business interruption also keep expanding (Cerullo et al. 2004). The problem with the notion of the BCP is, of course, that it intends to continue ”business as usual” at times of extreme stress. It lacks the recognition that a disaster management operation is essentially a different type of operation. The top priority of public organizations in a disaster situation is to save lives and help its residents. A BCP in the business field does not usually consider such disaster relief operations. Basically a disaster relief operation is an extremely labor-intensive task and though most of the municipalities make significant efforts to accomplish its provisions following an unexpected disaster, officials find it extraordinarily demanding.

After the Great East Japan Earthquake, the national government drew up a new guideline for the BCP that focuses on municipal responses immediately after a disaster. It sets out to show how to prepare disaster-proof technology to support disaster relief operations. However, this misses explaining how to respond to unpredictable disasters. A planned type of strategy should be distinguished from an entrepreneurial one (Mintzberg et al. 1985). A planned strategy means “precise intentions exist, being formulated and articulated by central leadership.” That kind of strategy does not expect any surprises. It tries to plan everything in advance of a calamity. On the other hand, an entrepreneurial strategy intends to adjust to unexpected, new opportunities arising from a given situation; “entrepreneurial strategies are strategies relatively deliberate but can also emerge unexpectedly.” Is it really possible to prepare every response in advance? Here, adaptability to unexpected opportunities should be considered. The question, then, is how to accomplish that adaptability.

To achieve it, we have two choices: one is to avoid major failures by managing demanding technologies to that effect, and the other is to maintain the capacity for facing unpredictable contingencies (Rochlin 1993; La Porte 1996). The latter is based on the likely occurrence of unexpected events. The following sections of this paper explore the means that might allow us to adapt to such a situation. To do this we look closely at what happened in the field during the earthquake of 2011.

## REALITY IN THE FIELD

Powerful earthquakes are not uncommon in Japan and in all probability will occur again. The largest earthquake on record in Japan is the Great East Japan Earthquake, which occurred at 14:46 Japan Standard Time on March 11, 2011, measuring 9.0 on the Richter scale.

Prior to the Great East Japan Earthquake, the second most destructive earthquake was the Great Kanto Earthquake that hit the Kanto region including Tokyo on September 1, 1923, measuring 7.9 on the Richter scale. According to official data, this earthquake left 104,619 people dead or missing, 190,000 buildings completely destroyed and another 212,000 buildings damaged by fire. It is generally estimated that it created 1.9 million evacuees. More recently, the Hanshin-Awaji Earthquake (7.3 on the Richter scale) on January 17, 1995, left 6,347 people dead or missing, 43,792 injured, 104,906 houses completely destroyed and another 534,780 houses heavily damaged (2006 Fire Defense Agency report).

A distinct characteristic of the 2011 Great East Japan Earthquake was, however, the extensiveness of tsunami damage rather than earthquake damage. A tsunami of up to 40 meters high hit the coastline, devastating cities and towns. The Fire and Disaster Management Agency reported 19,074 deaths, 2,633 persons missing and 6,219 injuries as of September 2014. It also reported 127,361 houses totally lost and more than 900,000 partially destroyed. The tsunami also cut all power supply to the cooling systems of the nuclear power plant in Fukushima, thereby causing a meltdown. Three and a half years after the disaster, by October 2014, 76,861 people still remained unable to return to their homes.

The recovery processes of the affected municipal governments depended heavily on the support role of ICT divisions (Sakurai et al. 2012). If ICT systems were to be impaired or unable to maintain the infrastructure of the systems storing resident and related information, the needed recovery tasks could hardly be executed. But this is what happened. Given the powerful magnitude of the earthquake, systems failure, including that of ICT systems, was wide-spread (Table 1). The possibility of such a failure had not been considered in standard disaster planning.

| **Municipalities interviewed** | | **Status of usage** [*1] **(March 11)** | | | **Timing of restoration (Days after the disaster)** | | | |
|---|---|---|---|---|---|---|---|---|
| | | Land lines | Mobile phones [*2] | The Internet | Land lines | Mobile phones | The Internet | Power supply (at the municipal government office) |
| Iwate Prefecture | *Miyako City* | × | Δ (1) | × | Approx. 20 days | - | 15 days | 15 days |
| | *Rikuzentakata City* | × | × | × | Details unknown | 7 days | 120 days at the temporary office | 3 days (only areas where emergency response headquarters were set up) |
| | *Kamaishi City* | × | × | × | 7 days | 7 days | 9 days | Approx. 120 days (19 days to server room and peripherals) |
| | *Otsuchi Town* | × | × | × | Approx. 45 days | 9 days | Approx. 70 days | Approx. 20 days (to the Central Community Hall), approx. 45 days (to temporary office) |
| Miyagi Prefecture | *Sendai City* | ○ | Δ (2) | × | - | 3 days | 2 days | 1 day (2days to the Information Systems Center) |
| | *Ishinomaki City* | × | × | × | 15 days | 15 days | 15 days | 15 days |
| | *Kesennuma City* | × | Δ (3) | × | 10 days | Approx. 10 days | 6 days | 6 days |
| | *Higashimatsu-shima City* | × | × | × | 6 days | Approx. 20 days | 6 days | 4 days |
| | *Minamisan-riku Town* | × | × | × | Approx. 20 days | Approx. 20 days | Approx. 20 days | Approx. 80 days (at temporary office) |
| Fukushima Prefecture | *Iwaki City* | ○ | ○ | × | - | - | 1 day | No power loss |
| | *Minamisoma City* | ○ (From March 12 ×) | | | 8 days | 8 days | 8 days | No power loss |
| | *Futaba Town* | ○ | Δ (4) | × | - | 7 days | 2 hours | No power loss |
| | *Namie Town* | × | × | × | Details unknown | Details unknown | 80 days | 1 day |

[*1]: Could not be used: ×, Could be used: ○, Could be used with some restrictions: Δ

[*2]: Information on the status of mobile phone usage as stated by interview respondents. Usage immediately after the disaster and timing of restoration varies with telecommunications service provider and area.

(1) Only few telecommunications service providers were operational.

(2) Usage varies with telecommunications service provider and area.

(3) Mobile phones functioned until around 10 p.m. on March 11.

(4) Mobile phones only functional for e-mail, not for phone calls.

**Table 1. Status of Communication Means and Timing of Restoration in Devastated Area (Sakurai et al. 2012; Sakurai et al. 2014)**

Table 1 summarizes the results of field interviews conducted from November 2011 through February 2012. Thirteen municipalities were selected for interviews to assess the damage caused by the earthquake to ICT and the local recovery process. The interviews revealed that electric power and connectivity were lost at exactly the most critical lifesaving phase. The interruption of communication and the loss of information system capabilities was a significant obstacle to the entire recovery process. People and organizations were deprived of data, records, and the processing capacity necessary to deal with an overwhelming situation. The negative effect was particularly noticeable at the municipal government level.

*Reality 1: ICT infrastructure ceased operating because of unexpected electric and connectivity failure*

To understand the deeper structure of a phenomenon it is important to explore reality more rigorously (Orikowski et al. 1991). We believe this would lead to better design requirements for appropriate communication channels. To give an example, look at a typical response to the earthquake in the city of Ofunato, in Iwate Prefecture. We interviewed the ICT division of the City Office in August 2011, five months after the earthquake, about the effect of the disaster and how ICT had responded to it.

In the Ofunato City area, the power supply was cut right after the earthquake. The main city office building was not damaged and could be used safely. Though they had an emergency power supply, it was limited to minor functions such as lighting. As a result, ICT could not operate, and the city was isolated from the outside area. Officials faced difficulties in understanding the extent of damage to the city and could not get a handle on what was happening at the time. The only remaining, reliable way to collect information was through personal, official effort. For the two or three weeks following the earthquake, almost all officials in the city office were searching for missing persons. The power supply resumed on March 14, three days after the earthquake, but only for the main office building. City branch offices and evacuation centers were still without power. In the main office, officials used fax and a satellite phone borrowed from the fire brigade to communicate with the outside world. A cell phone company offered a mobile cellular base station, which enabled city officials to twitter on March 18 with five cell phones provided by the same company as well. On March 24, a disaster response center secured a Note PC and an Internet phone connection via satellite. Recovery of lines of communication between the main office, branch offices, and evacuation centers took a long time but partial recovery was achieved by May 21 and the last line was recovered by the end of August.

Channels through which disaster related information could be relayed to residents were restricted to a fire truck, a message board set up in each evacuation center, and notes on paper. An official moved between evacuation centers delivering documents to provide information for supporting people who had escaped the disaster. Evacuee lists and requests for relief goods in evacuation centers were drawn up at each site but homeless people continually moved between evacuation centers, which made it difficult to know their effective whereabouts. This meant that city officials had to journey repeatedly between the main office and evacuation centers.

While Ofunato City struggled with securing additional communication channels between local officials, one of its friendship cities, Sagamihara City in Kanagawa Prefecture, far from the disaster area, helped out. An interview held with an official who was sent as relief staff by Sagamihara City in November 2011 sheds light on the nature of reestablishing communication in a calamity.

"Sagamihara City and Ofunato City enjoy a friendly mutual relationship and hold a festival together once or twice a year. Immediately after the earthquake, seeing that Ofunato was heavily damaged, people in Sagamihara collected contributions to support disaster victims in Ofunato. Sagamihara also sent city officials to help with the recovery in Ofunato. A team of seven left Sagamihara on the evening of March 13 and arrived in Ofunato the next morning. They understood at once that the biggest problem in Ofunato was the virtual communication failure. However, one of the team members belonged to an amateur radio club, and they managed to install amateur radio stations on the roofs of the main and branch offices. Electric power was supplied by emergency power generation. This enabled Ofunato City to communicate with evacuee centers and other branch offices. "

Sagamihara City continued to send their officials to Ofunato City as relief staff. They took actions autonomously and collected information on damage situations of the area, such as road conditions while Ofunato City put all staff into finding residents whereabouts. The reason why officials from Sagamihara performed independently is that they could understand what was needed from a same standpoint. Ofunato City appreciates Sagamihara and officials in Ofunato emphasize the importance of keeping connections during peacetime. It might appear as a friendship cities program that includes support in the disaster situation and joint fire drills with the assumption that the other city gets damaged by unexpected events.

*Reality 2: Ofunato City augmented its communication means with the help of amateur radio, i.e. with outside support that had not been foreseen*

What is at work here might be termed "bricolage," French for "tinkering," a notion advocated by Lévi-Strauss (1966) but more usefully defined by Weick (1993) in organizational management theory, where he applies it to improvised procedures with whatever materials are at hand. Chaotic situations normally disturb the fixed order of preconceived routine actions. At the same time, they restrict resourceful approaches in problem solving. Bricolage is seen to empower creative reactions under extensive pressure.

Another municipality, Takahagi City, realized the importance of creativeness under pressure. Immediately following the earthquake the power supply was cut for four and a half days and the city was totally isolated during this period. Ordinary daily life had been turned upside down and ordinary, planned-ahead solutions to predictable problems suddenly had no meaning. From this experience the deputy mayor of the city told us in May 2011, "We came to think that a small system relying on the scant resources actually available to us was going to be the most reliable means to communicate with the outside world in this situation."

## COMMUNICATION CHANNELS USED IN DISASTER SITUATIONS

While IS can ensure information quality and support decision-making in customary large-scale event management, there is a lack of research into what kind of systems would be useful in the event of a major disabling disaster (Chen et al. 2007; Ng et al. 2012; Reddy et al. 2009). To understand the requirements of communication systems in such calamities, we conducted a questionnaire survey on the means of communication between municipal offices and residents from August to September 2011. This survey took into account also disasters such as heavy rain and earlier earthquakes. The object of this survey was to determine the characteristics of responses to different types of disasters. Questionnaires were sent to all 1,746 Japanese municipalities and 280 valid forms (16%) were returned.

A disaster usually degrades communication modes (Simmons et al. 2003). During Hurricane Katrina in 2005, organizations in charge of recovery could not find any effective means of communication, especially in the first three days after the hurricane (Comfort et al. 2006). It was almost the same situation as in the research referred to previously. In our survey, to test disaster recovery from a broader perspective, the surveyed target area included municipalities throughout the entire nation, not only those strongly affected by the Great East Japan Earthquake.

To assess chronological variation in disaster recovery, we asked questions applicable to three chronological stages: within 24 hours, from 2 days to 3 days (after a disaster), and from 3 days to 7 days (after a disaster). The two key questions were: (1) what kind of information was collected and transmitted, and (2) what channel was used to collect and transmit that information. A breakdown of answers by disaster type was 115 answers citing earthquakes (including any other earthquakes that happened before the Great East Japan Earthquake) and 67 citing heavy rain (typhoon), while 2 citing landslide disasters and 96 came from respondents who had never experienced disasters and who were asked to base their answers on their own assumptions.

So far, in order to respond to a disaster effectively, the national, prefectural, and municipal governments have implemented disaster-proof channels such as satellite phones and external public announcement systems linked to an emergency alert system. These channels require a huge quantity of power and are for use in disaster situations rather than for daily routine tasks. During a disaster, municipalities are virtually the sole source of information concerning damage and recovery for their residents. Therefore, municipalities should collect accurate information and be in a position to transmit it effectively. However, can these disaster-proof channels really be called effective?

In order to determine in which situation disaster-proof channels are effective, channels are separated into two categories such as disaster-proof channels and daily-use channels. Disaster-proof channels include the fire brigade, police, satellite phones, message boards, cars and emergency alert systems. On the other hand, daily-use channels refer to fixed phone, mobile phone, fax, email, the Internet, and TV.

The following figures show the mean frequency of usage of each category of collection channels by chronological stage.

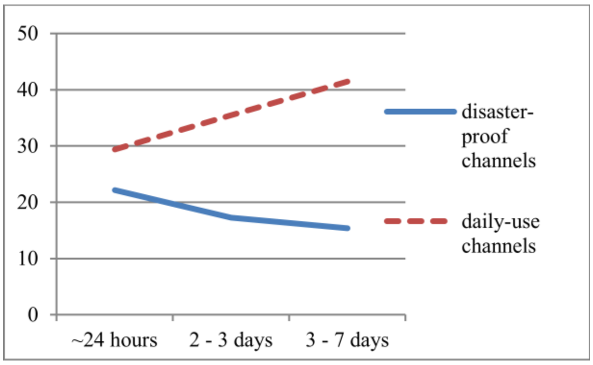



**Figure 1. Information collection – Earthquake**

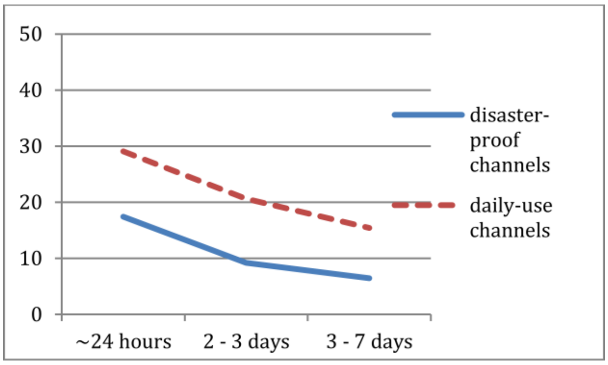
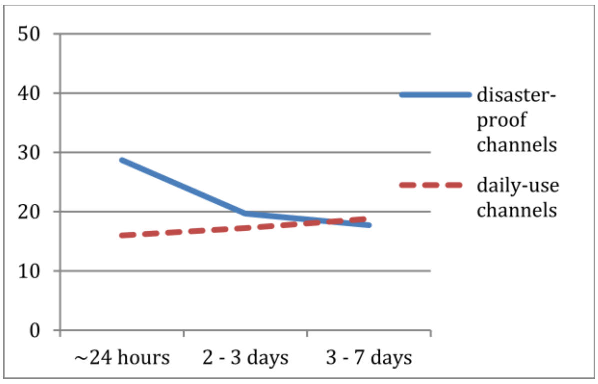



**Figure 2. Information collection – Heavy rain**

Results of a Wilcoxon signed-rank test indicate a statistical significant preference for daily-use channels in every chronological stage (Earthquake within 24 hours: $p=0.017$; from 2 days to 3 days: $p<0.0001$; from 3 days to 7 days: $p<0.0001$; heavy rain within 24 hours: $p<0.0001$; from 2 days to 3 days: $p<0.0001$; from 3 days to 7 days: $p<0.0001$).

The biggest difference between an earthquake and a heavy rain disaster is predictability. Earthquakes cannot currently be forecast, but there are advance warnings for heavy rain, and thus earthquakes tend to become a large scale disaster and its effects lasts longer than it in heavy rain. For unexpected disasters, such as an earthquake, the usage of daily-use channels in collecting information increases with the passage of time.

The following pair of figures shows the mean frequency of usage of each type of transmission channel by chronological stage. In this category, disaster-proof channels include the fire trucks, a prefectural disaster system, an external public announcement system, an internal receiver, and cars. Daily-use channels comprise community FM, mobile mail, Internet mail, home page, and twitter.



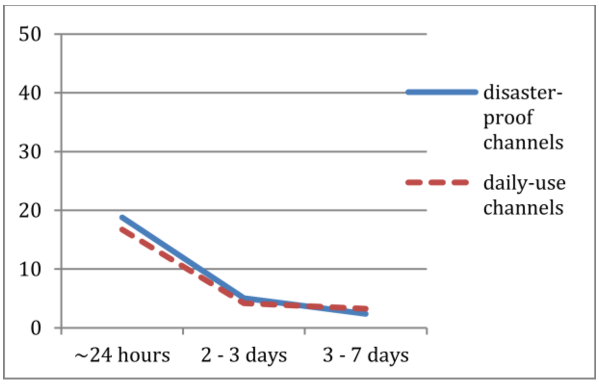



**Figure 3. Information transmission – Earthquake** **Figure 4. Information transmission – Heavy rain**

Only results covering the 24 hours following an earthquake show a statistical difference on the Wilcoxon signed-rank test (Earthquake within 24 hours: p<0.0001; from 2 days to 3 days: p=0.292; from 3 days to 7 days: p=0.568; heavy rain within24 hours: p=0.431; from 2 days to 3 days: p=0.541; from 3 days to 7 days: p=0.603).

Compared to the results for information collection, the figures for transmission show municipalities rely more on disaster-proof channels. However, in the earthquake category, daily-use channels get used more for transmissions as time passes. We also observe that in the case of earthquakes, the same trend applies to both information collection and transmission. This means information demand continues for a long time in the event of unpredictable disasters but decreases relatively rapidly under predictable conditions.

Conventional robust systems (disaster-proof channels) need to be especially effective within the first 24 hours following a disaster. However, such effectiveness cannot be guaranteed in the event of unpredictable catastrophes. While considering how to deal with an unexpected power or connectivity failure, officials may naturally search for familiar and frugal ways of handling it.

When we distinguish the following two types of communication; (1) among response agencies and (2) between response agencies and citizens, we get differences that communication among response agencies tends to rely on disaster-proof channels. On the other hand, communication between response agencies and citizens tends to rely on daily-use channels. This indicates that after an earthquake happens, communication needs that appeared as information collection and transmission from/to citizens increase as time passes. Further analyses on this transition over the time should be conducted as future efforts. This might be the point that municipalities that have not experienced disasters do not assume. They answered the questionnaire with their assumptions from the scope of the local management plan and the result does not show any differences or changes among each chronological phase. This leads us to realize that each category of (1) disaster types, (2) communication types, and (3) chronological phases should be considered when municipalities try to secure communication channels in severe disaster situations.

## DEVELOPMENT OF DESIGN PRINCIPLES

From the discussion of strategies (Mintzberg et al. 1985), the purpose of a disaster management plan should allow for an adaptable situation which recognizes new opportunities to formulate an effective response. But how can we produce such capabilities? Conventional disaster-proof channels are developed with the belief that they can be disaster-proofed through robustness, in other words, by avoiding failures. However, that is exactly where Ofunato City lost every effective means to share and deliver information and was totally isolated from the rest of the world following the massive earthquake. Unexpected situations will occur. We learned that the attempt to avoid failures by managing technology settings in advance is impossible. Thus, our research led us to consider how we can create capacity for meeting unpredictable failures (Rochlin 1993; La Porte 1996).

Technologies should support responding to particular task requirements with practical reasoning and empirical understanding (March et al. 1995). Conventionally, we believe that technology seeks to increase system performance. However, to develop the capability to adapt to new situations, we should consider the fact that people cannot easily accept new technology because it makes operators feel that the tasks they have to carry out are becoming more difficult as a result of it (Perrow 1983). The complexity of advanced technology as well as its heavy resource dependency is not desirable features of disaster-proof response channels. We saw that Ofunato City recovered communications inside the city area with an amateur radio. The notion of bricolage, as attempting procedures with whatever materials are at hand, explains this situation. Bricolage produces something from what’s available, by relying on people’s capacity to improvise in the face of uncertainty (Baker et al. 2005). An amateur radio is not new technology and disasters did not provide the impetus for developing it in the first place. It was simply available and required little power to run. We can say, then, bricolage is one requirement that enables responding to the unpredictable.

Normal accident theory (Perrow 1984) supports the notion of bricolage from system perspective with explaining differences between "tightly coupled systems" and "loosely coupled systems." According to this theory, tightly coupled systems have only one way to achieve their production goals while loosely coupled systems allow multiple paths. For example, Perrow uses instances of a nuclear and oil plants, saying "A nuclear plant cannot produce electricity by shifting to oil or coal as a fuel; but oil plans can shift to coal." As a result, loosely coupled systems can absorb failures because they can find redundancies and substitutions easily while tightly coupled systems should prepare these buffers in advance. This indicates the importance of preparing conditions that enables for field staff to improvise their responses.

*Design Principle 1: A system should be able to exploit whatever materials are at hand to create capabilities and resources for disaster relief*

Here the next question is how we can increase the likelihood of the success of bricolage. An IS is useful when there is a clear definition of requirements, and only when requirements are clearly defined it can provide an adequate solution (Beck et al. 2013). For a decade, the technology model has not been changed while information technology has changed greatly, becoming more complex, componentized, fragile, and its usage has become more diverse (Orlikowski et al. 2001). In terms of modeling information systems, an essential process is to define information needs (Bostrom et al. 1977). As the prior analyses shows, immediately after a disaster there is often lack of communication capabilities and information processing resources. Then, what kind of requirements is needed to handle these situations? The notion of frugal IS, which is defined as "an information system that is developed and deployed with minimal resources to meet the preeminent goal of the client" (Watson et al. 2013) provides us fundamental information requirements that systems should employ. The frugal IS should focus on the dominant problems of the first few days of a disaster. The four u-constructs (Junglas et al. 2006; Watson et al. 2002), such as "universality," "ubiquity," "uniqueness," and "unison" are a basis for establishing frugal system design principles. These four constructs represent information requirements. The notion of universality and ubiquity are the key concept when we realize bricolage. "Universality" is defined as the information drive to overcome the friction of information systems' incompatibilities (Junglas et al. 2006). This refers to universal usability, multi-functionality, and interoperability. This also mentions to standards (Watson et al. 2013) and encourages using open systems that can be readily integrated. "Ubiquity" is defined as the information drive to access information unconstrained by time and space. We indeed need to develop network connectivity to secure ubiquitous information access, enabling quick recovery after functions fail. Moreover, if ubiquitously available smartphones, standard PCs, and non-dedicated public Internet services can be used, the chances of creatively securing communication channels with "whatever available" resources increase. This will empower stranded people to help themselves before outside helps arrive.

The survey results lead us to three variables that are likely to affect the way of securing communication during a disaster such as disaster types, communication types, and chronological phases. It makes clear that people gets back to "habituated ways" when they have to produce a response under pressure (Weick 1993). This trend of finding solutions in one's regular situation appears strongly, especially in a situation where pressure continues for a certain period, such as an earthquake. It also becomes clear that disaster-proof channels were used especially in the immediate response stage (within 24 hours of a disaster) in both earthquake and rainfall episodes. The immediate response stage requires a high amount of communication between municipalities and outside relief agencies such as the fire brigade and police etc. Communication with their residents tends to prolong using daily-use channels and its information demands increase as time passes. These results lead us to stress the importance of finding the right balance between daily-use and disaster-only channels.

A problem that has troubled municipalities for a long time is the high cost of preparing disaster-proof channels such as an external public announcement system and a satellite phone. Building a master station for a public announcement system costs around USD 60,000. A relay station costs half that amount and an outside speaker costs around USD 3,000. In addition, installations require monthly maintenance with a cost of around a few hundred USD for each speaker. A satellite phone costs up to USD 2,000 for a single device and the service fee is around one hundred per month. Usually the national government compensates for the initial cost of installation though operating costs must be paid by municipal governments as long as the system is kept running. These channels are developed and used only in a disaster situation, which greatly limits the opportunity to train on them. When officials do need to use these channels, they may have problems operating them due to lack of familiarity.

Combining daily-use and disaster-only channels would be a useful solution. For example, the Japanese mobile company, Softbank Mobile Co., launched a new satellite phone called 202TH in 2014, which can be used in conjunction with the iPhone. A solid, hand-held bracket firmly holds the iPhone in place and connects to it via Bluetooth using a special application called “SatSleeve.” This enables the iPhone to be used as a satellite phone: making calls by phone number lookup, sending text messages, and transmitting data. Its initial and operating costs are almost half of a conventional satellite phone. This illustrates the possibility of daily-use channels as the foundation for multi-functional cover.

Here we can say a universal and ubiquitous design that enables bricolage to be exploited should be made a system feature.

*Design Principle 2: Exploit familiar channels as the foundation of disaster recovery and relief communications*

Both intuitive and smooth procedures for disaster relief tasks are important during catastrophic events, because they enable collaboration among players in the field and reduce complexity (Perrow 1983; Perrow 1984). The following two approaches for designing systems have been proposed (Banzhaf 2004): (1) a traditional design that contains complex principles and rules, and (2) an evolutionary design that contains a random combination of structural elements and follows simple design principles. Evolutionary system design contains a random combination of entities and it is realized by a bottom-up approach. In this sense, IS should support various demands and promote random combinations in the field flexibly. This design encourages novel combinations formed by materials or insights (Weick 1993). Design principles with the notion of universality and ubiquity should become the foundation for realizing multi-functional systems that enables easily finding of redundancies or substitutions during a disaster. Required minimal resources in making systems functional should also be embedded into the design. Perhaps we should follow simple design principles that reflect our daily life.

## CONCLUSION

Disaster management plans should fit the characteristics of the event that initiates the calamity and the types of outcomes it produces. As new technologies and materials are developed, people adapt new standards; in this sense a system may never be ultimately stable (Orlikowski et al. 2001). However, in a dire situation, people tend to turn to customary patterns for solutions. In view of such observations, a municipal government should make familiar communication channels the foundation of its disaster management plan. Emergency response plans within the chain of command and with given agency roles are essential (Gebbie et al. 2002). They stressed the importance of regular drills asserting that “plans that are never practiced or that are poorly understood will probably be useless.” On the other hand, Quarantelli (1981) points out that “realistic disaster planning requires that plans be adjusted to people and not that people be forced to adjust to plans (Gillespie et al. 1987).” A written emergency plan does not guarantee that actual operations will be effective. However, the process of planning that leads to the development of a written plan is extremely valuable (McLoughlin 1985). The process of planning gifts us knowledge of the community-area and resources at risk of damage and an assessment of the loss that would result from the occurrence of the event. The plan can identify hazard areas, such as flood plains, fault zones, landslide areas, and hazardous waste sites, and guide concentrated development away from them by designating them for open space or low-density uses, such as parking or recreation (Godschalk et al. 1985).

As the literature says, a conventional disaster management plan drawn by Japanese municipalities set the chain of command and the roles of each department. In addition, as mentioned in the previous section, it provides guidelines on how to equip facilities and raise resources. However, this focuses on systems robustness and misses the way to respond to unexpected disasters. The plan should assume possibilities that decisions might change according to disaster types, communication types, and chronological phases, and support effective/autonomous responses through its planning process. Moreover, training field staff and citizens is important. In this sense, fire drills with these considerations should be conducted as future efforts.

As technology advances, government at every level needs to test new technology to be sure it stands up to disasters and helps citizens overcome extreme conditions. An important finding from the Great East Japan Earthquake is that the failure of information and communication technology, including power supply, is unavoidable even though engineers and IS professionals keep on trying to make systems more robust. This leads us to realize that we should focus on strengthening daily-use channels, rather than trying to build a disaster-proof system. Adapting to new and unfamiliar situations during a disaster means creating conditions promoting the collaboration of people using materials readily available at the time.

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