PREPARING FOR CREATIVE RESPONSES TO "BEYOND ASSUMED LEVEL" DISASTERS: LESSONS FROM THE ICT MANAGEMENT IN THE 2011 GREAT EAST JAPAN EARTHQUAKE CRISIS

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Abstract

A survey of municipal government ICT divisions during and after the 2011 Great East Japan Earthquake and Tsunami crisis reveals the need for creative responses to "beyond assumed level" disasters. Complexity and diversity of the damage were simply too great for any plans to assume. Resident needs toward municipal governments affected were also diverse and changed quickly as time went by. Our research also indicates that there would be ways to strengthen the capacity for effective spontaneous responses. Creative solutions executed during the 3/11 crisis were enabled by the existence of open source software available on the Net and by skilled engineers capable of exploiting them. Frugal information systems will be useful to improve preparedness for creative responses in the future.

Keywords: Municipal Government, Information System, Disaster, Preparedness, Creative Response

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1. Introduction

Six month after the devastating Great East Japan Earthquake and the subsequent tsunami of March 11, 2011, LASDEC (Local Authority Systems Development Center) requested Keio University to conduct a survey on how ICT (information and communication technology) systems and organizations coped during and after the crisis. The objective of the survey was to formulate a standard business continuity plan (ICT-BCP) for the local governments so they may be better prepared for future disasters. Structured interviews of 13 municipal governments in the hardest hit areas were conducted from November 2011 to January 2012. The data was supplemented by interviews of officials in other municipalities, which were conducted outside of the LASDEC study producing this paper.

Shortly after the fieldwork had started, however, researchers came to realize that the complexity and diversity of the damage was huge among the municipalities surveyed. In fact, so huge that it would have been unrealistic to expect that a single BCP will provide adequate preparation for all local governments. Diversity of resident needs toward municipal government services also varied greatly. This would have made the task even more complex. Even if a comprehensive plan could have been drawn up, the cost of execution would have been prohibitive.

Based on our survey of the struggle of municipal governments to maintain critical resident life support services as well as the theoretical frameworks envisaged in public health crisis management literature such as Settle (1985), the authors came to the notion of "preparedness for creative responses". We define creative responses in this paper as autonomous actions taken by local officials to deal with damage that was not assumed in disaster response plans.

We assert the usefulness of this notion based on our observation that many unplanned activities were necessary to cope with "beyond assumed level" situations, though such activities were assisted by a range of readily available tools. In summary, we assert that preparation for disaster should include both action plans for assumed events AND development of creative response capabilities to deal with damage beyond the assumed level.

We believe that the notion of "frugal IS" (Watson et al., 2012) will be helpful in preparing for creative responses to future crises in municipal government ICT systems.

This paper consists of three main parts. The first part (Sections 2 and 3) gives an overview of the Great

East Japan earthquake and an account of the extent, diversity and complexity of the damage and the need for progressive adaptation in handling them.

The second part (Sections 4 to 6) describes damage assumed in the regional disaster response plans that were drawn up prior to the crisis. This allows us to identify damage that fell inside as well as outside of prior assumptions. We then describe how the municipal governments tried to deal with events that were beyond these assumptions. We also review concepts and theories around disaster response plans and disaster preparedness. Then we analyze how ICT systems were operated and performed in the actual disaster situations. Cases of two kinds of resident support systems, one prepared before 3/11 and another developed ad-hoc after 3/11, are analyzed.

Based on case analyses in the second part of this paper, the third part (Sections 7 to 9) incorporates "flexibility" and "frugal" concepts in proposing future ICT development policies. The goal is to allow municipal governments to prepare for a creative response at times of crisis.

2. The Great East Japan Earthquake

The Great East Japan Earthquake occurred at 14:46 Japan Standard Time on March 11, 2011. Measuring 9.0 on the Richter scale, it was the largest earthquake on record in Japan.

Prior to the Great East Japan Earthquake, the most destructive earthquake on record in Japan had been the Great Kanto Earthquake that hit the Kanto region including Tokyo on September 1, 1923, measuring 7.9 on the Richter scale. This earthquake left 104,619 people dead or missing, 190,000 buildings completely destroyed, and another 212,000 buildings burned according to data compiled by the Ministry of Internal Affairs. 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 partly destroyed (2006 Fire Defense Agency report).

A distinct characteristic of the 2011.3.11 Great East Japan Earthquake was, however, that tsunami damage was much greater than quake damage. Tsunami of up to 40 meters hit the coastline, devastating cities and towns. The Fire and Disaster Management Agency reported 16,131 deaths, 5,994 injuries and 3,240 missing as of January 2012. It also reported 128,497 houses totally lost and more than 900,000 partially destroyed.

The tsunami also destroyed all power supply to the cooling systems of the nuclear power plant in Fukushima causing a meltdown. As of January 1, 2012, 159,124 people from Fukushima had still not returned to their homes.

ICT divisions played an important support role in the recovery processes of all municipal governments. It would have been impossible to execute tasks without the support of ICT systems. ICT divisions were responsible for maintaining the infrastructure for various information systems.

ICT systems themselves were also hit. The interruption of communication and the loss of information system capabilities for operations were significant hindrances to the entire recovery process. People and organizations were deprived of the information and the processing capabilities necessary to deal with the situation. The effect was particularly noticeable at the municipal government level. There are 1742 municipal governments in Japan as of October 1. 2012. In the three-layer (national, prefectural and municipal) structure of Japanese government, municipal governments are closest to citizens and serving their daily needs directly.

Most significantly, municipal governments are in charge of keeping resident information which serves as the foundation for government.

3. Crisis diversity, complexity and progressive adaptation

Both the extent and the scale of the earthquake damage were diverse, as the damage was due to combinations of quake and tsunami impacts. The affected areas were also very large with different geographical conditions.

The expectations of ICT divisions and the requisites for and processes towards recovery varied greatly along several variables. The variables included structural damage to government facilities, server rooms and loss of data. There were severe doubts as to whether power supply and network connectivity could be resumed immediately and whether communication tools such as cell phones would remain functional during the crisis. Another unknown was the degree of mass emergency evacuation to locations outside the affected area.

Also notable was the need for progressive adaptation in the situation. As the situation changed over time, requirements for dealing with it also changed.

In the initial phase, immediate response measures in the municipalities that experienced major devastation focused on saving lives and guiding survivors to evacuation centers, with little priority given in some areas to reopening resident service counters (though there was a sense of urgency regarding the need for access to residents' personal information in order to facilitate rescue operations). Some ICT divisions even dispatched employees to do relief work, with just skeleton staff remaining at the office. At these municipalities as well, providing support to the affected people at various post-disaster stages was difficult without the use of ICT (including information systems). It became more than apparent that post-disaster expectations toward ICT divisions change as time passes.

4. Could a uniform plan be effective?

4.1 Planned response to assumed level damage

In general, regional disaster response plans drawn up by each municipality specify the scope of action to be taken by the relevant organization during a disaster, such as setting up disaster response headquarters and confirming the safety of residents. Some plans also clarify the role of each operational division in the event of a disaster.

After the disaster response headquarters were started up, many of the municipalities dispatched personnel for tasks such as operating evacuation centers and transporting goods under instructions from those headquarters. Further, although several of the regional disaster response plans stipulated that the role of ICT divisions during a disaster would be information services for the residents, this was not possible because key communication means were disrupted.

The response measures summarized below require a large number of people working at the disaster site to carry out numerous activities, including creating lists of survivor names and other information, manning resident service counters to issue Disaster Victim Certificates to qualify for disaster relief and other support systems, distributing relief money, accepting applications for temporary housing, and tearing down damaged buildings and clearing debris. Municipal governments are mandated by law to perform these tasks. ICT supports this role.

The disaster response measures taken by the ICT divisions of 13 municipalities surveyed can be primarily divided into the following:

1) Documenting evacuee names and other information (on paper and computer)

2) Restoring operation of information processing systems:

-Upgrade of existing systems

-Development and introduction of new systems

3) Verifying information in various lists with previously documented resident information

4) Issuing of Disaster Victim Certificates

Documenting personal information is an extremely labor-intensive task and though most of the municipalities made significant efforts to complete this unexpected post-disaster duty, employees found it extraordinarily demanding.

4.2 Damage beyond assumed level

Damage observed at the 13 municipal government office buildings following the earthquake and tsunami was well beyond assumed situations. Casualties and damage occurred in the form of -

- Loss of lives of majority of executives in the higher tier
- Collapse of government office buildings
- Damage to servers, ventilation systems and other equipment
- Loss of data
- Suspension of power supply Damage to telecommunications cables and equipment (disruption of communications)
- Destruction of office automated systems
- Difficulty in getting employees and other personnel to the government office building
- Inability to enter the server room (malfunction of electronic locks due to power outage)
- Relocation of the server room
- Relocation of administrative functions

In addition, in areas affected by the nuclear accident, access to the government offices became difficult for local and outside personnel despite no apparent damage to the buildings themselves. The difficulty of relocating data servers and administrative functions outside the region became increasingly apparent.

Post-disaster risks could potentially give rise to a number of adverse situations. In particular, a power failure will upset the operation of information processing systems and disrupt communication with the outside. Hence measures to ensure uninterrupted power supply are of utmost importance. During the survey as well, most of the municipal governments emphasized the need for a stable power supply. The time taken for commercial power supply to be resumed at the 13 government office buildings varied greatly by municipality, ranging from one day to several months. Although it may be close to impossible to anticipate the time required for power supply to be restored, measures must be implemented to clarify beforehand the tasks that must be carried out during a power failure and to create systems that will ensure uninterrupted power supply to essential ICT equipment. Initiatives must also be taken to prepare for other responses such as the relocation of some administrative functions in the event of prolonged power outages.

4.3 Response to beyond assumed events by ICT divisions

With regard to ICT divisions, however, none of the 13 municipalities surveyed had drawn up action plans that included business continuity planning. Also, responses by the respective ICT divisions at the time of the disaster were mainly based on their own discretion.

The following is a typical timeline of responses, produced on the basis of activities conducted by employees of ICT divisions at the municipalities that were surveyed in the months immediately following 3/11. Staff -

1) checked the condition of the servers and other equipment in the server room immediately after disaster struck;

2) confirmed resident whereabouts, and helped with transporting goods and other tasks related to the operation of evacuation centers;

3) worked on restoring information processing systems, networks and other related equipment within the facility after power supply was resumed;

4) studied the introduction of and developed information processing systems that can be used for disaster response activities;

5) worked to restore public data networks in the region.

5. Plan vs. preparedness

Settle (1985) argued that emergency management should be financed in four stages, i.e., mitigation, preparedness, response and recovery. Shoaf et al. (2000) adopts the same four-stage model in the analysis of disaster management. In the context of this model, our research is about preparedness and response stages. We place added emphasis on preparedness for responses to damage that was not assumed before the event.

An important aspect of preparedness is planning. Gebbie and Qureshi (2002) emphasized the importance of emergency response plans within the chain of command and with given agency roles. They also emphasized the importance of regular drills asserting that "plans that are never practiced or that are poorly understood will probably be useless". On the topic of drills, Watkins (2000) points out that FEMA (The Federal Emergency Management Agency) is adopting a five category model, i.e., orientation, drill, tabletop, functional, and full-scale.

As mentioned above, all of the 13 municipalities we interviewed in the LASDEC survey had regional disaster response plans. The plans defined the chain of command and the tasks to be performed. ICT divisions, however, were simply beyond the scope of the plans in spite of their importance. We are supportive of the national government initiative to equip all municipalities with ICT-BCP.

While we support better planning, our field research also revealed that the extent and diversity of damage can go far beyond any prior assumptions. This implies that even if ICT-BCP existed, a uniformly prepared set of responses would have been insufficient to meet the diverse and rapidly changing needs of the residents.

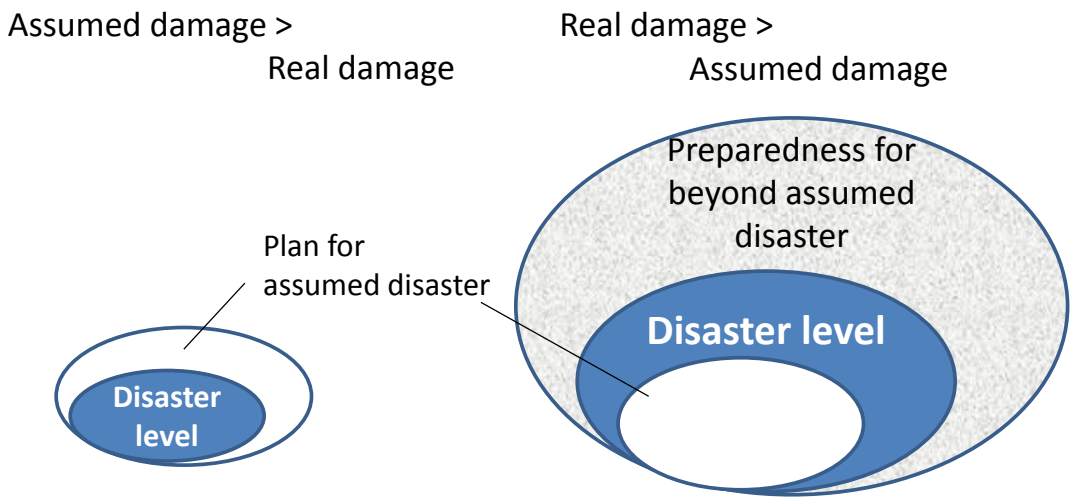
This by no means reduces the importance of planning. It is naturally useful to make predictions of damage and make plans to respond to the situation. Determination of the chain of command is critical and it is wise to stock up on supplies based on a careful estimation of need. Such plans should also be widely shared by all people concerned.

At the same time, we recognize the importance of flexibility in decision making in executing disaster management plans (Kunreuther and Miller, 1985). To respond to changing situations, strategic incorporation of current information is essential.

We propose to apply the concept of preparedness when thinking about increased official capacity in flexible responses to unexpected events (See figure).

In this regard, preparedness is at the opposite end of "plans" that are made based on predicted and assumed damage. Damage within assumptions can be dealt with by plans. What we need in addition is to prepare for the extra capacity required for creative responses to damage beyond the assumed level.

Figue 1. Preparedness for beyond assumed disaster



6. Comparative study of disaster victim support operations

6.1 Uses of the planned solutions and their limits

Disaster Victims Support System is a Linux based, comprehensive post disaster support system endorsed by the National Government. (Henceforth called the Nishinomiya system after the municipal government that developed it). It was developed after the 1995 Hanshin Awaji Earthquake that killed thousands to prepare for future similar events. Source code (programs that can be read and written by humans) for the software had been made openly available to other municipal governments in 2005 and to everyone including private companies after the Great East Japan Earthquake in 2011.

In spite of its good intentions and investment, the system was not utilized as expected in the relief efforts of the Great East Japan Earthquake.

Instead, municipal governments opted to use simpler measures such as the use of Microsoft Excel. Even municipal governments where the Nishinomiya system was used had to modify original software to suit local requirements. In short, all of municipal governments affected had to conduct ICT development work at a time when people were starving and freezing outside. We believe this situation was unavoidable. We also believe that such processes can and should be properly prepared for without extraordinary demands on resources and time.

It would serve the risk management community well to analyze the reasons for the limited application of the Nishinomiya system.

One reason for the less than expected application of the package was the lack of time to learn how to operate the software in a disaster situation. It is notable that much ICT resources were spent in the most critical moments to get up and running systems that would meet the immediate demands of diverse, local situations.

Information processing systems that were restored or newly introduced and the timing of putting them into effect differed across municipalities. Two main types of systems can, however, be identified:

-Systems based on resident information with links to all other government functions

-Systems for individual functions (issue of Disaster Victim Certificates, distribution of relief funds, etc.)

The Nishinomiya system was one example of an existing system that is based on resident information and links to all government functions. Survey respondents were asked questions about the introduction of this system. Although none of the municipalities had installed the system before March 11, 2011, Miyako City, Ishinomaki City, Kesennuma City, Minamisanriku Town and Iwaki City have introduced it since then though selectively geared to only those features of the system that are required for their individual operations. Miyako City utilizes the system to manage the distribution of relief funds; Ishinomaki City for the issue of Disaster Victim Certificates; Kesennuma City for the management of debris removal; and Minamisanriku Town to manage distribution of relief funds and occupancy of temporary housing facilities.

Following the disaster, many municipalities considered the introduction of the Nishinomiya

system, but were forced to defer it for the following reasons:

-Installation on data servers was not successful

-Data processing is required, making use of the system cumbersome

-A drop in performance was expected when handling large volumes of data

-Study and modification to the system could not be completed in time for issue of the certificates

-Operational differences with the developer (Nishinomiya City) regarding the format of the Disaster Victim Certificate and other issues

-Information upload regarding disaster victims was already completed using different application software

In hindsight, all of the problems mentioned in the above comments may have been avoided if preparations had been made in normal times to configure the system beforehand and train personnel to be able to upload resident information immediately in the event of a disaster. The reality was that ICT divisions were too busy to prepare for slim possibilities of catastrophe. And when the time came, the planned tool lacked familiarity among the officials who then avoided their use.

6.2 Creative response to impending necessity : Case Tagajo City's Disaster Victim Management System

Ashenhurst (1972) asserted that information systems "must have" modifiability, in addition to capability (to perform its intended functions) and stability to be responsive to organizational requirements.

Juergens (1977) argued that "well functioning" systems have unsatisfied users and stressed the importance of user participation. In the context of this paper, these calls for modifiability can be interpreted as calls for developing capacity among users to execute creative responses themselves.

The table below lists creative responses in ICT by 13 municipalities and their execution dates. We recognized an action as a creative response when either original software was developed, or a modification was made to the package (i.e., the Nishinomiya system) software by changing its source code.

Table 1. Creative Responses by Municipal Governments Surveyed (As of January 2012)

Municipalities surveyed		Example of creative responses	Date
Iwate Prefecture	Miyako City	Modified the Nishinomiya system Developed Kyoto-u-system*	Mid-May Late-December
	Rikuzentakata City	Developed residents safety checking system by open source software	Mid-March
	Kamaishi City	Developed Kyoto-u-system*	Mid-April
	Otsuchi Town	Developed original victim support system (Supported by National Research Institute for Earth Science and Disaster Prevention) Developed Kyoto-u-system*	Late-April around May

Miyagi Prefecture	Sendai City	Modified existing tax collection system to develop victims support system	Early-May
	Ishinomaki City	Modified the Nishinomiya system	Early-May
	Kesennuma City	Developed original victim support system with Microsoft Access	Mid-April
	Higashimatsushima City	Developed original victim support system	Mid-April
	Minamisanriku Town	Modified the Nishinomiya system	November
Fukushima Prefecture	Iwaki City	Developed original victim support system	Late May
	Minamisoma City	Developed checking residents safety system by Microsoft Access Developed original victim support system	March April
	Futaba Town	Developed checking residents safety system with Microsoft Excel	March
	Namie Town	Developed checking residents safety system with Microsoft Excel Developed original victim support system	March Late-March

*A system created and provided through collaboration between industry, government and academia, under the guidance of the Disaster Prevention Research Institute, Kyoto University.

Even among those adopting the Nishinomiya system, Miyako, Ishinomaki, and Minamisanriku had to modify the system to meet their needs. As many post-disaster tasks cannot be foreseen, it is often difficult to determine beforehand what information installation will be required (and what will not) during a disaster. Following are some examples of items that cannot be confirmed beforehand and require some form of technical support to upgrade the Nishinomiya system as may be needed after a disaster has occurred.

-There are no records on evacuee relocation history

-Information on temporary housing choices of evacuees cannot be uploaded

-Information on management of relief goods cannot be updated

-There is no feature to record transactions at resident service counters

The operation of information systems to deal with disaster response measures, including that of the Nishinomiya system, requires more than just installing the system on a server. As explained above, emergency preparedness measures must be taken to enable installation of resident information immediately following a disaster. Training to ensure business continuity and the provision of support to victims must also be implemented beforehand.

In addition, steps must also be taken to ensure speedy coordination between systems to enable extraction of information from the existing resident information system and conversion to the new format.

Tagajo City where we conducted interviews outside of the LASDEC inquiry is an example of a municipal government that developed a new system during the recovery period. They did so because the Nishinomiya system could not meet its needs. Tagajo City opened its citizen support center on April 1, 2011. The center's primary tasks were to identify resident whereabouts/contacts, damage inflicted on their

homes/properties, and to provide adequate information on the relief programs.

An information system became necessary to record the history of consultancies and relate them to resident records. System development to meet these needs started just five days before the service began to run. Faced with lack of resources including time, the city relied on open source software on the Net. Necessary adjustments and additions were made to the software parts and were then integrated to fulfill the needs.

Requirements for the system were 1) to give consistent advice to each resident based on integrated records of all advice given to him/her on separate occasions, 2) to have an integrated and simultaneously accessible database that can be accessed from multiple help desks, 3) to be available for long term use as residents would need long term assistance.

A popular CRM (customer relationship management) system in the commercial world, SugarCRM, was chosen as the core engine. SugarCRM could operate on common browsers and some parts were offered free of charge. Thus by limiting the use of the software to narrowly defined areas (records of advice, advisory officials, and advice provided), the city could freely customize and use the system.

Other tools used were PHP programming tools, MySQL database tools, Apache server software and Eclipse development environment, all available on the Net. Development was carried out at the city's server room that had survived the disaster. As the tools were open systems that required no more than browsers and came with little installation burden, existing equipment could be used. Numbers of terminals could be added liberally as many of the tools were also license free without the worry of paying more for licensing and/or violating copyright.

The system operates in a series of steps:

Step1: Setting up resident identification. Data was imported from City Government official resident records and can be searched as the key for subsequently adding records of advice.

Step2: Inputting resident problems. Interview records of residents were input. If a resident visits multiple times, new records are added on top of previous records under a single key.

Step3: Issuing consultancy records to advisees. To give sense of assurance to residents, copies of interview records and advices are handed to persons advised. Advisees can bring their copy to subsequent consultations.

The system was put in operation on April 1 in time for the opening of the center. One hour guidance was given to the advising officials that operated the system. No major problem occurred and minor functional additions were made to the system as the system was running. As of April 30, 2012, the system served over 30,000 consulting occasions with 700 officials, including officials that were sent by other municipalities as relief staff.

7. Preparedness for creative responses in ICT

7.1 Frugality and flexibility

As illustrated above, systems development became necessary at critical times of the 3/11 disaster. Plans that are based on assumptions of damage are important, but we have to also prepare for damage that exceeds our assumptions.

Preparedness for creative responses is therefore necessary.

How then, can we improve our preparedness? We would like to consider this within the scope of ICT.

The notion of "frugal information system" (Watson et al., 2012) provides a clue.

Frugal information defines an information system that is developed and deployed with minimal resources to meet the preeminent goal of the client. According to Watson et al. (2012), a "4U" information related design concept should be incorporated into systems built with frugality. The concept includes: Ubiquity (The drive to access information unconstrained by time and space), Uniqueness (The drive to know precisely the characteristics and location of a person or entity), Unison (The drive for information consistency) and Universality (The drive to overcome the friction of information system incompatibilities).

We would like to verify the usefulness of this concept by applying it to the cases we observed in our survey.

7.2 4U in Great East Japan Earthquake cases

In the case of Tagajo, while successfully having started to serve residents with consistent consulting, lack of unison in the systems subsequently became an issue. While consistency existed within the domain of consulting, it did not connect with other government services. Various databases were created for different tasks. Data about individuals were stored in different databases. With the lack of an effective link code, it was difficult to integrate the databases later.

This experience suggests that lack of unison leads to failures in uniqueness and universality. Faced with the problem of scattered databases, officials in Tagajo City subsequently generated individual IDs for linking purposes and went on to integrate the systems. This action improved the efficiency of the operation greatly.

While unison, uniqueness and universality were lacking in the Tagajo system - at least in the initial phase - we can say that ubiquity firmly existed. The system was developed with integrated open software that adopted a standard interface and was available on the Internet.

The central government with its endorsement of the Nishinomiya System, was at the other end of the 4U spectrum. It had uniqueness, unison and universality features. In theory, it also had ubiquity feature as it was made with open software on Linux. However it was stored in a locked area that was not openly accessible. It also required highly skilled engineers. Faced with technical requirements that the officials were not faced with on a daily basis, they tended to avoid using the system in the fear they might not be able to launch and support it. Many municipalities that opted to avoid the Nishinomiya system also lacked the skill level of Tagajo City officials and instead relied on Windows-based systems with package software such as Excel that was readily available.

Looking at above cases, it is important to incorporate flexibility into the building and operating of information systems to enable creative responses in emergency situations.

To this end, we may add a fifth U, i.e. "ordinary usability". Ashenhurst (1972) makes the point that information systems should feature

usability, operability, and maintainability to effectively fulfill users' needs.

Our survey confirms that it was far easier to fulfill usability criteria for systems that were used on an ordinary basis than for special purpose tools that were used infrequently. Thus we should try to use tools that we generally use, rather than applying special tools designed for extraordinary occasions. It came down to the use of common browsers in the Tagajo case. It was the use of equally common Microsoft packages in others. Officials being familiar with such tools at times of an emergency are more likely to realize creative responses.

In addition to the application of the frugal IS concept, the importance of preparation for flexibility in ICT development should be emphasized. Tools that are not used daily cannot be used at times of emergency. Staff should be trained to use frugal and flexible systems in normal times.

8. Employing cloud computing for creative responses

Loss of important data, such as birth and resident records as a result of Great East Japan Earthquake is prompting the municipal governments to consider the use of emergent cloud computing technologies. Cloud computing is an information system architecture in which data and applications are stored in the network instead of on local machines such as PCs and servers. This technology can be used both to backup data in secure locations and to provide information processing capabilities to critical areas quickly. It is at the core of national government policies to prepare for any other potentially big disaster.

We believe the introduction of cloud computing technology can and should be used to construct frugal information system with 4U (or 5U) features. This will be achieved with: (1) the use of the Internet and cloud infrastructures, (2) shared open systems for common "tasks" on the cloud, and (3) the development of locally customized interface software to fulfill the diverse needs of each municipality.

Separation of application software from the infrastructure is a major feature of this proposal. By having a nationally run infrastructure, small municipal governments will be freed from developing costly infrastructure. Cloud computing resources can then be flexibly applied via the Internet to whichever localities are in need of using the resources to build creative responses to events beyond any assumed level. In normal times, only minimal resources can be used. That will help to save costs in small municipalities with weaker financial foundations.

Use of cloud computing technology is still limited in Japan at this point in time, but externalization (as opposed to internal ownership) of resources will be essential in enhancing the capabilities of municipal governments to handle ever increasing information processing needs.

Structuring of application software constitutes a second opportunity. We observed that while there is great diversity in the requirements for information processing, critical processes such as identification of residents, as well as many legally defined processes such as issuance of relief funds, remain common. Thus, by separating the two and building a common engine for the common tasks, municipal governments can focus on areas that they need to customize. This will greatly reduce cost and more

importantly time to develop systems that meet the emergency needs of the residents. In summary, the use of cloud can add flexibility to the municipal governments operations in executing creative responses when they become necessary.

A prerequisite for adopting this technology is to have a reliable infrastructure. Here again, the system can be frugal. The infrastructure should provide minimal connectivity universally and ubiquitously. Having an open interface above all, is essential.

Software performing the common tasks as described in the previous section can also be considered part of the infrastructure. The cost of developing such software can be shared by a coalition of municipal governments to lessen the burden for each. An open interface for such systems should be created so that municipalities can creatively custom design whatever systems are required to meet ad hoc needs without having to develop basic systems from scratch.

9. Conclusion

"Beyond assumed level" is a term that many Japanese heard almost every day in the days after the Fukushima nuclear plant accident following the tsunami. What became evident in that experience was that when you assume a certain extent of damage, you tend to forget preparing for damage beyond that level. We were unprepared for the worst tsunami in recorded history because we prepared assuming the previous worsts in our history. It is easy to argue that we should have prepared for even worse, but that would have been economically unrealistic. It will continue to be unrealistic to prepare for an infinite level of risks.

The Great East Japan Earthquake taught us that events beyond an assumed level do happen, and we should somehow deal with them creatively. What we need to do now is to train ourselves to be creative and prepare the kind of tools that support creativity effectively.

References

1. Ashenhurst, R. L. (1972), "Curriculum Recommendations for Graduate Professional Programs in Information Systems", Communications of the ACM, Vol. 15, No. 5 , pp. 363-398.
2. Gebbie, K., M. and Qureshi, K. (2002), "Emergency and Disaster Preparedness: Core Competencies for Nurses" The American Journal of Nursing, Vol. 102, No. 1, pp. 46-51.
3. Juergens, Hugh F. (1977)," Attributes of Information System Development", MIS Quarterly, Vol. 1, No. 2, pp. 31-41.
4. Kunreuther, H. and Miller, L. (1985), "Insurance versus Disaster Relief: An Analysis of Interactive Modelling for Disaster Policy Plannning", Public Administration Review, Vol. 45, Special Issue, pp. 147-154.
5. Sakurai, M. and Kokuryo, J. (2012), "Municipal Government ICT in 3.11 Crisis: Lessons from the Great East Japan Earthquake and Tsunami Crisis", Berkman Center for Internet & Society, Working paper, http://papers.ssrn.com/sol3/papers.cfm?abstract_id =2095192.
6. Settle, A. K. (1985),"Financing Disaster Mitigation, Preparedness, Response and Recovery", Public Administration Review, Vol. 45, pp. 101-106.
7. Shoaf, K., I. and Rottman, S. J. (2000)," The Role of Public Health in Disaster Preparedness,

Mitigation, Response, and Recovery", Journal of Prehospital and Disaster Medicine, Vol.15, Issue.4, pp.18-20.

8. Watkins, S. (2000), "Developing Statewide Emergency and Disaster Preparedness Expertise", Journal of the American Institute for Conservation, Vol. 39, No. 1, pp. 165-172.
9. Watson, R.T., Kunene, K.N. and Islam, M.S. (2012)," Frugal information systems (IS)", Information Technology for Development, forthcoming