Disaster Warning Broadcasting Process Management: A Case Study of Landslide from Typhoon Wipha at Izu-Oshima in 2013

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1. Introduction

Early warning is one of the priority actions addressed by the Hyogo Framework for Action (UNISDR, 2007). The traditional disaster warning system is likely to be the "linear communication systems" (i.e., starting from monitoring and detection systems, followed by data analysis and prediction, and finally communication to public) (Sorensen & Sorensen, 2007, p. 185). With the current various advanced technologies, there are many ways and sources where people can access information. The public can receive warning information from a multi-channel approach (Sorensen & Sorensen, 2007). No matter how much disaster prevention has been prepared, we cannot guard down the disaster awareness because anything can be happening. The comprehensive warning systems require the following actions: "Detect the presence of a hazard", "Assess the threat posed by that hazard", "Determine the population facing risk from that hazard", "Inform the population", "Determine appropriate protective actions that may be taken", "Direct the public to take those actions", and "Support the actions taken by the public" (Coppola 2011, p. 280-281). In this study, we would like to zoom in on the part of informing the population or so-called broadcasting.

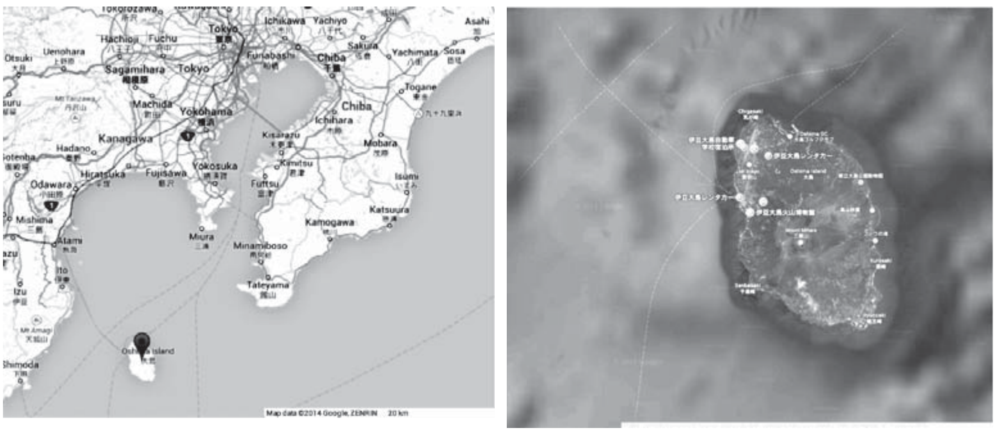

Fig. 1 Izu-Oshima Map
Note. Source: Google Maps (2014a, b).

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In mid-October 2013, Typhoon Wipha (International Designation: 1326; Japanese system: H25 Typhoon No. 26) extensively attacked Japan. Among many typhoon-encountered areas, Izu-Oshima (see Fig. 1), a 91.06-km^2 island, which is administered by the Tokyo Metropolitan Government, experienced heavy rain, many landslides, and debris flows (see Fig. 2). This issue catches the interest of many media and press, such as Hofilena (2013a, b), House of Japan (2013), Kyodo (2013), and Yamaguchi (2013). This study aims to understand the warning broadcasting system of this case study through a business process management (BPM) perspective.

Fig. 2 Typhoon Wipha's Affected Area at Izu-Oshima.
Note. Taken on January 20, 2014 at Izu-Oshima.

In Section 2, a review of the conceptual background is described, followed by an explanation of the research design and methodology in Section 3. In Section 4, an analysis of the case study is briefly summarized. Finally, the conclusions and suggestions are discussed in Section 5.

2. Conceptual Background

Based on Perinforma (2012), the levels of communication can be categorized into 4 levels: (1) "*Social correspondence*", (2) "*Cognitive correspondence*", (3) "*Notational correspondence*", and (4) "*Physical interaction*". The ontological level is the communication in the social correspondence (a.k.a. "*Performa level*"). The infological level is the communication in the cognitive correspondence (a.k.a. "*Informa level*"). The datalogical level is the communication in the notational correspondence (a.k.a. "*Forma level*"). Lastly, the physical level is the communication in the physical interaction (a.k.a. "*Medium level*") (Perinforma, 2012). In order to understand the entire essence of the organization, the managerial perspective focuses on the ontological level, while the infological level provides the analyzed or calculated information and the datalogical level provides the data used mainly by the operational perspective. The bottom level is the physical level that is used to be a communication medium, such as Internet, telephone, fax, etc. The message of communication appears in each level but in different forms.

Disaster management is a typical example of an inter-organizational process. The warning system in Japan has been introduced and studied by many researchers, such as Kamigaichi (2004), Ozaki (2011), and Yamasaki (2012), in the technical aspects. This paper gives attention to the process management, applying the business process management and the enterprise engineering modeling language to the warning broadcasting process. In fact, the overall ontological level of the warning system in Japan has been mentioned in Leelawat et al. (2013). However, that research studied the entire sketch. Thus, this paper further studies the broadcasting part of the warning system through the case study of the recent disaster, the Typhoon Wipha.

3. Research Design and Methodology

This study applies a qualitative approach using interview data. The study seeks to understand the overview and issues related to the disaster warning broadcasting system, focusing on the case of Izu−Oshima which was affected by the Typhoon Wipha in 2013. During January 20−21, 2014, we visited the affected area of Izu−Oshima and visited the Izu−Oshima Town Office in order to conduct face−to−face, semi−structured interviews with the related officers (see Fig. 3). The interviewees included the Chief of Disaster Prevention Division of Izu−Oshima Town and the Japan Meteorological Agency (JMA) officer at Izu−Oshima Town. Example questions included the following points: “*What kind of duty or activity did your organization provide in the disaster?*”, “*Who was the person who initiated that step?*”, and “*What kind of information was necessary in that step?*” The collected interview data were analyzed and visualized by Design & Engineering Methodology for Organizations (DEMO) (Dietz, 2006; Perinforma, 2012). The Organization Construction Diagram (OCD) (i.e., a diagram which describes the actor role who is the initiator and executor of the transaction) is used to represent the warning broadcasting system in this study.

Fig. 3 Interview at Izu−Oshima Town Office.
Note. Taken on January 20, 2014 at Izu−Oshima

4. Warning Broadcasting System Analysis

According to JMA (2013a, c) the terminology of warnings in Japan has different criteria among the disaster type. The summary is presented in Table 1. Since August 30, 2013, JMA has launched the ‘Emergency Warnings’ for alerting people to “possible catastrophes caused by extraordinary natural phenomena” (JMA, 2013a). For the meteorological disasters (i.e., heavy rain, heavy snow, high waves, storm, storm surge, snowstorm), there are three indices of criteria (JMA, 2013c): (1) rain (for heavy rain), (2) typhoon or similar (for heavy rain, high waves, snowstorm, storm, storm surge), and (3) snow (for heavy snow).

Table 1. Japan’s Disaster Warning Classification (JMA, 2013a, c)

Disaster Type	Warning Classification	Description of Criteria
Earthquake	Emergency warning	Seismic intensity of 6−lower or more
	Warning	Between seismic intensity of 5−lower and 6−lower
	Forecast	Between seismic intensity of 3 and 5−lower or more than magnitude of 3.5
Heavy rain	Emergency warning	“Heavy rainfall with a level of intensity observed only one once every few decades is predicted in association with a typhoon or similar” or “Heavy rainfall is predicted in association with a typhoon expected to have a level of intensity observed only once every few decades or an extratropical cyclone with comparable intensity”
	Warning	“Chance of catastrophe”
	Advisory	“Possible development of serious adverse conditions”
Heavy snow	Emergency warning	“Heavy snowfall with a level of intensity observed only once every few decades is predicted”
	Warning	“Chance of catastrophe”
	Advisory	“Possible development of serious adverse conditions”
High waves	Emergency warning	“High waves are predicted in association with a typhoon expected to have a level of intensity observed only once every few decades or an extratropical cyclone with comparable intensity”
	Warning	“Chance of catastrophe”
	Advisory	“Possible development of serious adverse conditions”
Snowstorm	Emergency warning	“A snowstorm is predicted in association with an extratropical cyclone expected to have a level of intensity observed only once every few decades”
	Warning	“Chance of catastrophe”
	Advisory	“Possible development of serious adverse conditions”
Storm	Emergency warning	“A storm is predicted in association with a typhoon expected to have a level of intensity observed only once every few decades or an extratropical cyclone with comparable intensity”
	Warning	“Chance of catastrophe”
	Advisory	“Possible development of serious adverse conditions”
Storm surge	Emergency warning	“A storm surge is predicted in association with a typhoon expected to have a level of intensity observed only once every few decades or an extratropical cyclone with comparable intensity”
	Warning	“Chance of catastrophe”
	Advisory	“Possible development of serious adverse conditions”
Tsunami	Emergency warning	Tsunami is over 3 m
	Warning	Tsunami is between 1 m and 3 m
	Advisory	Tsunami is between 20 cm and 1 m
	Forecast	No tsunami to slight sea level changes

Volcanic eruption	Emergency warning	Residential−area warning; “Eruption or possibility of eruption that may cause serious damage in residential areas and non−residential areas nearer the crater” or level 4 & 5 of volcanic alert
	Warning	For non−residential areas near the crater, “Eruption or possibility of eruption that may severely affect places near residential areas (possible threat to life in such areas)” ; for around the crater, “Eruption or possibility of eruption that may affect areas near the crater (possible threat to life in such areas)” or level 2& 3 of volcanic alert
	Forecast	“Volcanic ash emissions or other related phenomena may occur in the crater (possible threat to life in the crater)” or level 1 of volcanic alert

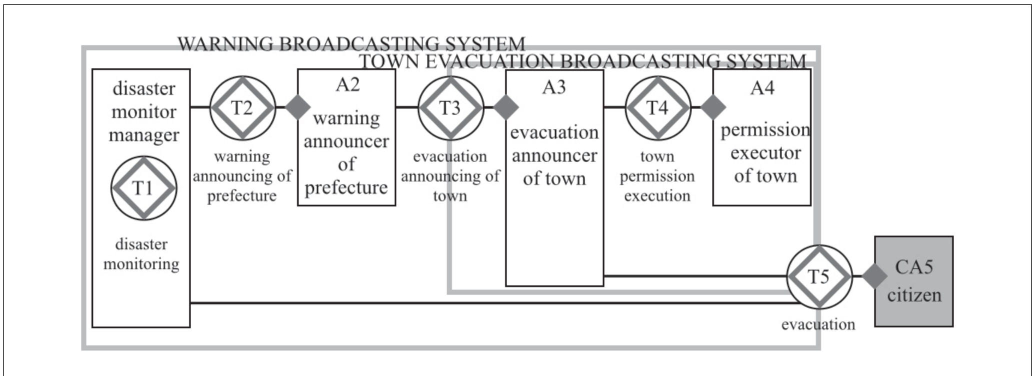

Fig. 4 OCD of Warning Broadcasting System (Pattern #1) for non−earthquake, tsunami, volcanic eruption

Based on the interview data, we analyzed the system following the DEMO modeling language. We drew the OCDs of the warning broadcasting system. We found that there are two patterns of the broadcasting system for this case. The first one is the OCD of the normal disaster scenario (as happened in mid−October 2013) (Pattern #1) and the second one is the scenario of earthquake, tsunami, and volcanic eruption (Pattern #2). Fig. 4 shows the OCD of the Pattern #1, and Fig. 5 shows the OCD of the Pattern #2.

As shown in Fig. 4, there are two boundaries in the system because we would like to show the actor roles in the town−level evacuation broadcasting system (i.e., Izu−Oshima Town level). The larger boundary represents the warning broadcasting system. First, the disaster monitor manager (i.e., actual actor: JMA) executes the disaster monitoring. When the possible disaster is detected, the disaster monitor manager requests a warning announcer of prefecture (i.e., actual actor: Tokyo Metropolitan Government) to announce/relay a warning, depending on the criteria (see Table 1). In the case of a disaster other than an earthquake, a tsunami, or a volcanic eruption, it is necessary to request an evacuation announcer of town (i.e., Disaster Prevention Division of town office) to make an evacuation announcement. Before announcing, the evacuation announcer of town has to request a town permission executor (i.e., actual actor: Mayor or Deputy Mayor), who makes a decision whether to announce an evacuation message or not, to provide permission for broadcasting. Then, the evacuation announcer of town can announce and request people to evacuate in case of the

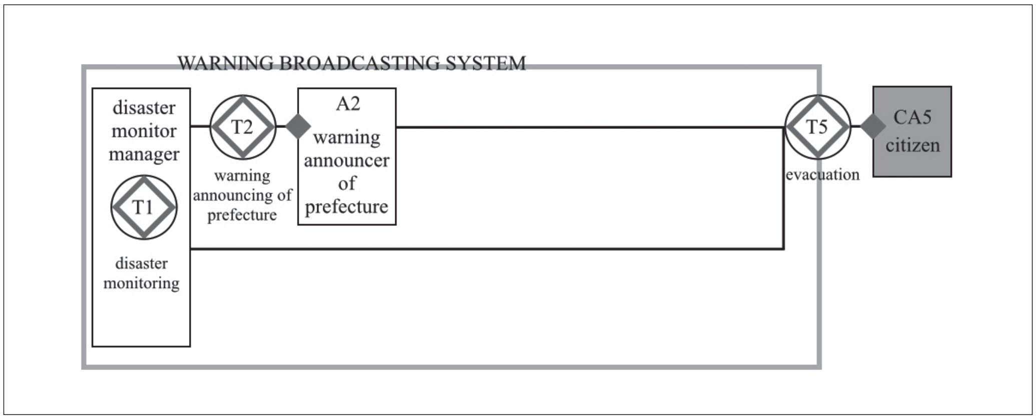

Fig. 5 OCD of Warning Broadcasting System (Pattern #2) for earthquake, tsunami, and volcanic eruption

Table 2. Comparison between Pattern #1 and Pattern #2

Characteristics	Pattern#1	Pattern#2
Actor role	4 actor roles	2 actor roles
Transaction	5 transactions	3 transactions
Responsibility	Responsibility belongs to A2, A3, and A4 (especially A4 in the scope of town)	Responsibility belongs to A2
Time	More time consumption between the first initiator and the last executor because there are more transactions which require decision making	Less time consumption between the first initiator and the last executor because there are less transactions

emergency warning level.

In Pattern #2, as shown in Fig. 5, the beginning is quite similar to the previous pattern, except for the latter part, where the prefectural evacuation announcer (i.e., actual actor: Tokyo Metropolitan Government) can execute an evacuation announcement directly and automatically through the alarms installed in many places on the island. The characteristics of two patterns are summarized in Table 2.

It can be seen that the type of disaster is used to determine the pattern of the broadcasting process because the three severe disasters (i.e., earthquake, tsunami, and volcanic eruption) require immediate evacuation once any of them occur. At the same time, other disasters require more decision-making transactions at the town level, even for the emergency warning level.

In our case study, when Typhoon Wipha attacked Japan, the storm and heavy rain generated huge mudslides along a 2-km stretch of mountains, which destroyed dozens of houses. According to the interview data and report (Tokyo Metropolitan Government, 2013), there were some issues learned from this case. First, in practice, if we look at the medium used in the town evacuation announcing (T3), Tokyo Metropolitan Government used a fax machine to relay the message from JMA to the town office in the evening. However, the person in charge left the office during that time, and unfortunately, it was a period of heavy rain. After 6 hours had passed, this message was received when the Chief of Disaster Prevention came back to the office the next day (October 16th) at approximately 1:30 a.m.; nevertheless, it was too late to issue the evacuation at that time because it was in the middle of the night, and the rain was too heavy to evacuate. Second, the actor of permission executor of the town actor role was not on the island due to a business trip; therefore, the town permission execution could not be executed in a short time. As a result, there was no evacuation announcement on the island. Landslides and mudslides caused 35 fatalities and 6 missing people (JMA, 2013b).

5. Discussions and Conclusions

The disaster warning-evacuation broadcasting system in the Typhoon Wipha of Izu-Oshima case has been analyzed by applying DEMO. In addition, some suggestions are given in this section.

It can be understood that the current disaster broadcasting system of Izu-Oshima consists of two patterns, based on the type of disasters. While Pattern #2 (warning broadcasting system for earthquake, tsunami, and volcanic eruption) applies the automatic alarm, Pattern #1 (evacuation broadcasting system for non-earthquake, tsunami, and volcanic eruption) has two other actor roles (i.e., the town evacuation announcer and the town permission executor) and two other transactions (i.e., the town evacuation announcing and the town permission execution). When comparing the two patterns (see Table 2), Pattern #2 requires less time due to the fewer numbers of actor roles and transactions. One suggestion is the change of the business rule for cautioning. Instead of using an automatic alarm for only earthquakes, tsunamis and volcanic eruptions, the rule can be changed from the disaster-type-based pattern to be based on the level of impact or severity. The critical level of disaster, which requires 'emergency warning' level, can follow the Pattern #2 system, such that the citizen can evacuate immediately.

The completion of the transaction comprises request, promise, state, and accept (Dietz, 2006; Perinforma, 2012). From the OCD of Pattern #1 (see Fig. 4), the town warning announcing lacked the 'promise' step because no person received the faxed message at the local office. The suggestion is to change the assignment of the actor (as shift work) to this actor role for 24/7; then, the request can be received (and promised) at all times.

Apart from the previous suggestion, which concerned the issue of the ontological level, we also can change the physical level or the medium of communication. Many new mobile or communication technologies can be selected for use in this transaction. One possible approach is to use technology that will allow the local officer to access the information anytime and anywhere. Along with Sorensen and Sorensen' s suggestion (2007), because the advances in technology during the information era has reached many people, the trend of the disaster warning system can change to a multi-channel approach, such as mobile phones and devices (Sorensen & Sorensen, 2007).

Lastly, as Coppola (2011) mentioned, making a decision whether to issue or announce a warning is one of the most difficult steps for a disaster manager because it can create panic among the public or create a "crying wolf" problem. Therefore, it requires time for consideration. By applying Pattern #2 to the 'emergency warning' level of all disaster types, it should reduce the time needed for the decision-making process.

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