Post-disaster Emergency Communication for School Evacuation Shelters: A Spatial Analysis of the Sendai Municipal Disaster Prevention Radio System
Takashi Oda and Gen Shoji

1. Abstract
This study examines the effectiveness and challenges surrounding the use of municipal emergency radio communication systems in public facilities such as schools and community centers. Actual radio traffic logs—provided by the Sendai City Board of Education and recording 440 exchanges of critical information mainly passed from the emergency shelters to the municipal emergency management headquarters during the Great East Japan Earthquake (M9.0) on March 11, 2011—were analyzed spatially and in GIS. Fortunately, Sendai City had just completed the installation of a 800 MHz radio system in all public schools by February 2011, due to realization of national radio frequency use. The GIS analysis shows that such new communication technology is capable of improving the quality of communications (e.g., mobile-phone-voice) down. The analysis also identified challenges in the operation of such radio equipment. Based on the evaluation by timeline and geographic distribution, this report demonstrates how such technology can be utilized best, not only from technological perspectives such as multi-channel access controls and area zoning, but also for non-technical training for post-disaster life-line communication. Sendai—the birthplace of the DRM framework—can be one of the leading models for this initiative.

2. Introduction
More than 20,000 people were lost in the Great East Japan Earthquake and Tsunami (M9.0). Many people remain displaced, even though almost five years have passed since March 11, 2011. Sendai City, Miyagi Prefecture is the largest municipality by population among municipalities affected by the disaster. The city consists of a mix of coastal and inland geography (Figure 1). More than 1000 people were killed or went missing in Sendai alone, mostly due to the coastal tsunami damage.

3. Methods: Spatial Analysis of Radio Logs
This case study is based on actual radio traffic logs recorded by officials at the Sendai City Board of Education, provided as courtesy by the BSS to our Center. The log contains date/time and names of schools with the city's office communication, as well as short descriptions of the messages transmitted by the radio. From the time of the initial earthquake at 14:46 JST, March 11, to 00:00 JST, March 14, a total of 440 communications were made, with the maximum radio traffic time per hour at 16:00-17:00 hrs JST on March 11 (15.2% of the total). The analysis was made of the communication for school evacuation shelters across the city, while shelter operation situations were correspondingly less included the increasing number of evacuees in the gymnasium (Photo 2). Immediately after the earthquake, ordinary telecommunications such as the landline and mobile phone systems became overloaded, and those in the affected areas had difficulty in communicating critical information through the digital communication technologies that people heavily rely on these days (Figure 2).

4. Results
For the first 3 hours post-disaster, confirmation of student safety constituted the main messages across the city, while shelter operation situations were reported from the time of the earthquake until the early morning of March 12. Geographical analysis in coastal areas where massive damage was caused by the tsunami, the transmission regarding the student's safety and shelter operations continued. In-downstream areas with high population density and tsunami which happened to be working in the city center, the shelter operation situations also included the increasing number of evacuees in the gymnasium (Photo 2). In contrast, in the areas that were relatively less affected in the southern and western parts of Sendai, such critical information was correspondingly less common; communications mainly discussed possible future school reopening and operations.

5. Considerations
Critical pieces of information, including safety confirmations and search and rescue information, were communicated by the then newly introduced radio system as time when other means of communication were not fully consistent, working, or reliable. Some school principals had been recently instructed how to use the system, including the facts that it was semi-portable and could be used outside with a portable antenna. Yet, according to city officials, the system was not fully utilized; some users ran out of batteries, while others were not able to effectively pass the messages within the allotted three-minute limits of each radio call. The number of channels was limited to 14 pairs and one control frequency (20 frequencies). The users needed to be aware that if one person covered the system, then other communications would be affected due to the limited channels. This overcrowding of the channels led to some claims that the system was not effective because it did not result in dependable communications, as with mobile phones. The city has now introduced emergency using control of radio communications depending on where the severe damage is. Only the city control offset can regulate radio transmissions. Also, based on the lessons, Sendai City has distributed portable power generation to all schools that can be connected to the radio. More training is needed to train the users of the radio. The city now encourages school administrators to regularly use the radio for non-emergencies so that they can familiarize themselves with its further effective use. Suggested uses include conducting roll calls at a designated date/time.

Further research can propose similar effective training based on the actual lessons from the 2011 disaster and other existing knowledge and skills on simple radio communications.

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