

UC Berkeley

Working Papers

Title

Response Operations Following the Chichi, Taiwan Earthquake: Mobilizing a Rapidly Evolving, Interorganizational System

Permalink

<https://escholarship.org/uc/item/6417p6bs>

Author

Comfort, Louise

Publication Date

2000-12-31

RESPONSE OPERATIONS FOLLOWING THE CHICHI, TAIWAN EARTHQUAKE:

Mobilizing a Rapidly Evolving, Interorganizational System

Louise K. Comfort

Visiting Professor, Research Center for Urban Safety and Security
Kobe University, Nada, Kobe, Japan 657-8501

E-mail: comfort@kobe-u.ac.jp

Working Paper 2000-5

Prepared for submission to the *Journal of Chinese Industrial Engineering*, January 26, 2000.

***Working Papers* published by the Institute of Governmental Studies provide quick dissemination of draft reports and papers, preliminary analysis, and papers with a limited audience. The objective is to assist authors in refining their ideas by circulating results and to stimulate discussion about public policy. *Working Papers* are reproduced unedited directly from the author's page.**

RESPONSE OPERATIONS FOLLOWING THE CHICHI, TAIWAN EARTHQUAKE: Mobilizing a Rapidly Evolving, Interorganizational System

Introduction

Rapid mobilization of response personnel, equipment, supplies and assistance following a major earthquake represents a set of complex, interorganizational tasks that tests the existing policies and capacity of public institutions. Such mobilization requires lateral coordination of actions simultaneously among responsible agencies within each level of jurisdiction: city, county, national, and international. It also requires vertical coordination among agencies across multiple jurisdictional levels as the event escalates in impact and danger. This process is further complicated by the urgent stress of operating under disaster conditions, where time is the crucial factor in saving lives. Yet, the organizational requirements for mobilizing a rapid response system following a major earthquake run counter to the typical pattern of hierarchical organization of administrative activities in public organizations (March and Simon, 1993; Simon, 1981; Kaufman, 1985; Fesler and Kettl, 1991).

In an effort to bring order and efficiency to the extraordinarily difficult and complex task of mobilizing response to sudden, severe threats or natural hazards, nations develop emergency plans. These plans specify the goals of emergency response, assign specific responsibilities to designated agencies at each jurisdictional level, and seek to identify a set of tasks that need to be performed by each agency under emergency conditions. Taiwan, for example, had a National Emergency Plan (revised, 1994) that was in effect at the time of the 9.21.99 ChiChi Earthquake in Central Taiwan. Such plans, however, largely reflect the logic of daily administrative practice and frequently prove inadequate under the heavy demands and dynamic conditions of actual disaster operations.

The discrepancy lies not in the act of planning for emergencies, which is essential to minimize risk, but in the concept of managing disaster response that underlies the formal plan. Daily administrative practice assumes a capacity to control an organizational process by defining goals, tasks, actors and resources that characterize the process, and a set of known rules that govern their interaction. In a disaster environment, managers often confront situations that they had not anticipated, or find that the basic infrastructure for administrative performance has been disabled, or discover that existing rules and resources do not match the difficult conditions which they face. Managers are then left to improvise actions to cope with extraordinary demands, often inventing new solutions under the intense pressure for action. In such an environment, the initial conditions in which the disaster occurs govern the range of responses that the managers at different locations in the designated emergency response system are able to take. Managers quickly discover that critical conditions are often beyond human capacity to control.

Under such conditions, informed action at multiple points within the system of designated response organizations becomes an alternative strategy to a rule-based system of administrative control. The response system becomes self organizing, as constructive action by one organization enables others to extend their performance, which, in turn, facilitates responsible action by the next set of organizations in an interdependent process. Self organization, or the capacity to reallocate energy and action in response to urgent needs, (Kauffman, 1993; Comfort, 1994; 1999) requires a sociotechnical infrastructure that facilitates the search, exchange, and absorption of information in response to

rapidly changing conditions. Self organization allows simultaneous action both laterally and vertically among organizations participating in a disaster response system. It depends upon access to timely, accurate information regarding the dynamic conditions of the disaster among all participants in the evolving response system, as well as feedback from actions taken to inform a common knowledge base for the system.

Instances of self organizing behavior emerge in response to virtually every disaster (Comfort, 1999), as responsible professionals seek to minimize risk and alleviate danger to their communities. Yet, in most disaster response operations, these instances are sporadic and often unconnected to one another. I propose that efficiency and effectiveness in mobilizing disaster response operations increase more rapidly if aided by lateral processes of self organization guided by the shared goal of protection of lives, property and continuity of the community, than if organized through vertical procedures of command alone. This proposition assumes the existence of an appropriate sociotechnical information infrastructure to facilitate rapid search, exchange, and feedback of valid information among the participants in the disaster response process. Under the best conditions, self organizing processes function within the existing set of legal policies and procedures to enable practicing managers to adapt dynamically to the complex demands of disaster operations. Under the worst conditions, existing rules and procedures obstruct the flexibility required for self organization, and hinder innovative actions by experienced managers.

Response operations following the ChiChi, Taiwan Earthquake of September 21, 1999 showed elements of this tension between the need to establish administrative control through known rules and procedures for disaster operations and the need for self organizing processes in response to dynamic conditions. The former is most frequently achieved through vertical coordination and the latter through lateral coordination. Finding the appropriate balance between the two types of actions in disaster operations is a critical task for disaster managers.

In this paper, I examine this tension between administrative control and self organization by addressing four related issues. First, I present briefly the initial conditions of the technical, organizational, and cultural environment that characterized the communities of Central Taiwan which were stricken by the 9.21.99 Earthquake, and governed the context of disaster operations.¹ Second, I analyze briefly the existing administrative structure of the emergency response process presented in the 1994 National Emergency Response Plan² that was in effect at the time of the 9.21.99 earthquake, identifying a set of critical points of interaction among the participants essential for effective response. Third, I compare the stated policies of the existing Emergency Plan with reports of actions taken by a set of fifteen practicing disaster managers who played significant roles in disaster operations at different jurisdictional levels.³ These reports represent only a small subset of actions taken during the entire disaster response process and are necessarily incomplete. Yet, they illustrate key points in the response process where the demands of the disaster conditions exceeded the existing capacity for administrative control, and self organizing processes by responsible managers at their respective levels of jurisdiction proved essential to protect lives and property in the stricken communities. Finally, I offer a set of recommendations to enhance the capacity for self organization in disaster response.

The Context of Disaster Operations

In the early morning hours on Tuesday, September 21, 1999, a powerful earthquake struck Central Taiwan. At 1:47 a.m., cities, towns and villages were left in total darkness throughout much of the island as the earthquake knocked out electrical power transmission stations, disrupted telephone communications, collapsed buildings, shut off water and sewage distribution systems, and damaged roads, railroads and bridges. Stunned by the violence of the event, residents of stricken communities and public officials with emergency responsibilities struggled to cope with the demands of extraordinary destruction.

The earthquake occurred on the Chelanpu Fault, with the epicenter located at ChiChi, Nantou County. The magnitude registered $M_s = 7.6$ Richter, $M_I = 7.3$ Richter. The depth measured 1.0 km., shallow in comparison to other large magnitude events. The duration of shaking was timed at 40 seconds, a long period of seismic activity. The rupture extended 70 - 80 km. in length, with the rupture velocity measured at 2 km./sec. The intensity of this earthquake was not anticipated on the Chelongpu Fault, classified as moderately active in Taiwan. Waves of aftershocks continued in the days immediately following the main shock, with two registering 6.8 Richter within the first 100 hours.⁴ The effects of the earthquake were widespread, causing significant damage in 5 counties, with 90% of the damage occurring in Nantou and Taichung Counties. Six additional counties reported minor damage, for a total of 11 out of Taiwan's 21 counties incurring losses from the earthquake.

This sudden, devastating event claimed a high toll in lives and property, with the total of number of dead reported at 2,405; number of missing: 39; number of patients treated for injuries: 10,718 of whom at least 1,000 required hospitalization; number of persons rescued: 5,004; and number of persons needing evacuation: 4,685. More than 31,534 buildings were reported totally collapsed within the disaster region, with 25,506 reported as partially collapsed.⁵ Twenty-seven towns reported serious damage, and aboriginal communities were affected in isolated mountain areas. These figures give scant profile to the level of destruction in the damaged communities, or to the scale of human suffering endured in the event.

Using a set of indicators developed from the analysis of 11 other major earthquake disasters (Comfort, 1999:65-66), I reviewed data on three aspects of the disaster environment to develop a preliminary assessment of the initial conditions that shaped the emergence of the disaster response system following the 9.21.99 Earthquake. The three categories include indicators for 1) Technical Structure; 2) Organizational Flexibility; and 3) Cultural Values, which are listed in the Appendix.

Technical Structure

The built environment of the cities and towns in the disaster region typically included concrete structures with some seismic design features, such as steel rebar reinforcements and ceiling-to-wall connectors. Buildings that failed most frequently were four-to-six story buildings with soft first-story designs, in which the first floor was used for commercial purposes and the upper stories for residential apartments.⁶ In the larger cities, 12-to-15 story residential buildings with only 1 basement collapsed, indicating inadequate structural design to withstand the stress of a $M_w 7.6$ earthquake. Buildings located close to the fault line failed, indicating inadequate assessment of the soil structure and vulnerability of the site to seismic risk prior to construction.⁷ Yet, building codes had been

revised as recently as 1996,⁸ and damage to buildings in the area was likely limited significantly by the codes in effect. Cities and towns had fire departments, which in the smaller towns relied on volunteer sub-teams coordinated by the County Fire Chief. A communications capacity, primarily telephone, existed among local organizations during normal times.

But the collapsed concrete structures required heavy equipment and advanced search and rescue techniques to rescue victims trapped under rubble, which were not available in the damaged communities. Local towns initiated search and rescue operations with limited equipment and untrained personnel. Most trapped people were rescued within 48 hours by family, friends and local fire department personnel, who used hand tools and physical strength to free victims from the rubble.⁹ Most damaged communities did not have access to either the trained personnel or the equipment to carry out adequate SAR operations. On a range of indicators, I would classify the technical structure existing in the disaster area prior to the 9.21.99 earthquake as low-medium.

Organizational Flexibility.

Organizing response to this disaster was particularly difficult, given the wide area affected by the earthquake and multiple sites that suffered severe damage. Information regarding damage to affected areas was slow and incomplete in the first hours after earthquake. Not all towns established emergency operations centers immediately, and in most of the affected towns, existing emergency planning and preparedness proved inadequate for an event of this magnitude. Mobilization of personnel and equipment for disaster response over five counties demanded a complex set of operations and coordination of actions among multiple agencies, governments, private and nonprofit organizations. While most decisions were taken quickly, the logistics required to enact them were not readily in place, resulting in delayed implementation.

International search and rescue teams arrived with advanced technical equipment, trained personnel, but late in process. Search-and-rescue teams arrived from a total of 20 countries, but rescued a total of 6 live persons. International assistance was complicated by the unique situation of Taiwan in the international community. Humanitarian assistance was delayed in several instances by political constraints. Although individual managers made extraordinary efforts to respond to the demands of the earthquake, these efforts were hampered by insufficient knowledge of seismic risk in the region and its impact upon the built environment and communities, lack of timely, accurate information from the multiple sites affected, inadequate emergency preparedness training, and a damaged infrastructure for communication. Based on the observed indicators, I would classify the flexibility of the organizations with disaster responsibilities following the ChiChi Earthquake as low-medium.

Cultural Values

A striking cultural openness to new information, new ideas, and new modes of operation characteristic of the Taiwanese community shaped in significant ways the evolving disaster response operations. Professional managers at every level exhibited a clear “bias toward inquiry,” or acknowledged effort to discover what were the effects of the earthquake on the communities; why the buildings, roads and bridges failed; and how both the technical and organizational infrastructure could be better designed to prevent such losses in the future. This effort was matched by the remarkable social cohesion of the Taiwanese people, who contributed generously to disaster relief

from every city and county in the island nation. Having faced extraordinary hardship in their history, the Taiwanese people appeared to respond to the severe earthquake as the current challenge which they must overcome.

A process of inquiry, evaluation and documentation of response operations by government and research agencies reinforced the courageous response of ordinary Taiwanese people to the sudden, urgent circumstances of the disaster. Although there was relatively little integrated information available to policy makers in reference to seismic risk in the affected region prior to the disaster, governmental agencies and national research universities and centers quickly mobilized a knowledge base for the affected counties and towns. In doing so, they used advanced information technologies such as GIS¹⁰ and a distributed information system to link separate knowledge bases of the responsible national ministries into a shared knowledge base accessible to policy makers with responsibilities for disaster operations.¹¹ Information regarding the disaster was also made available to the public via Web sites established specifically for that purpose. Although the knowledge base was not available to guide the immediate response operations, it was developed quickly following the earthquake with the intention of using it to facilitate the complex process of recovery operations, and to learn from this event in preparation for improving response to future earthquakes.¹²

This focus on research, evaluation and development of new methods in response and recovery operations represents an innovative development in disaster management, led by the national governmental agencies and the research centers and universities. It also reflects a bias toward inquiry by governmental ministers in Taiwan, many of whom hold Ph.D. degrees in a range of disciplines and have had formal training in research methods and analysis. This is an unusually favorable situation for transforming a destructive event into an opportunity for organizational learning to mitigate future seismic risk. It further demonstrates a productive collaboration between governmental agencies with responsibilities for disaster management and research institutions with capacity for data collection, analysis and professional evaluation. Based on the observed indicators, I would classify the cultural openness of the Taiwanese people as high.

Integrating the preliminary rankings on three sets of indicators, Technical Structure = Low/Medium; Organizational Flexibility = Low/Medium; and Cultural Openness = High, I classify the response system that evolved following the 9.21.99 ChiChi, Taiwan Earthquake as an “Operative Adaptive System” (Comfort, 1999:72-73) . That is, there was sufficient capability in place to enable a response system to evolve and to function in a reasonably coherent way, but the system itself was not yet self organizing at all levels, especially during the initial hours following the earthquake.

The Legal Framework for Disaster Response: The 1994 National Emergency Plan of Taiwan

A review of the National Emergency Plan of Taiwan, enacted on January 20, 1994,¹³ reveals a logical policy of mitigation directed toward reducing the effects of natural disasters. Like all plans, however, the difference between the stated policy and the actual implementation may be significant. This analysis is not intended to criticize the plan in a negative way, but rather to present it as the legal basis for the organization of disaster response operations in Taiwan. Public agencies at national, county, city and town levels were operating within the legal framework of this plan, and had

expectations for the performance of disaster response functions by organizations at the respective jurisdictional levels based upon the stated policy.

Organized to guide the three broad areas of prevention, response and recovery in disaster management, the plan provides a general framework for the mobilization of disaster response following earthquakes. First, the plan addresses the establishment of natural disaster prevention and rescue centers and emergency preparedness training on a national scale. It states that each ministry and every jurisdiction of government – national, county, city, township -- is responsible for establishing a natural disaster prevention and rescue center. Accompanying this responsibility is the added requirement of developing a detailed emergency plan for their respective ministries and jurisdictions and the conduct of emergency preparedness exercises at least once per year.

The plan includes in prevention the task of monitoring critical infrastructure, roads, bridges, harbors, dams, power plants, railroads, airports, water storage facilities, as well as engineered buildings, for their vulnerability to damage from natural hazards. This task is assigned to several ministries, Transportation, Board of Trade, Internal Affairs, as well as county and city governments. It also includes the responsibility to establish performance criteria for the relevant sites, and to provide adequate facilities and equipment to maintain performance, or respond to threat, should it occur. Related to this task is the identification of areas – urban and rural – that are vulnerable to natural disaster, and control of these areas through limited use and zoning regulations. This responsibility adds the Ministry of Agriculture to the number of agencies and jurisdictions listed above.

Further, the plan acknowledges the need for research and continuing collection of data regarding risk as part of its prevention strategy. These functions would contribute to the development of an information system related to seismic risk, and new designs and technologies for earthquake-resistant structures. In the plan, research, data collection and development are assigned to the Ministries of Internal Affairs, Transportation, Agriculture and the Board of Trade.

Second, the plan allocates response functions to the respective ministries, with the active engagement of county, city and town governments. It includes the media in communicating news of the event, but local governments were assigned the primary responsibility for conducting an immediate survey of their jurisdictions and communicating that information to the next level of government. Responsibility for emergency rescue operations is assigned to each administrative agency, as well as county, city and town governments. The plan designates responsibility for damage assessment to the Ministry of Internal Affairs, the Labor Relations Department and the Board of Trade. Specific functions such as safety inspections for hazardous materials facilities or management of water resources affected by an earthquake are assigned to their respective bureaus or ministries, Environmental Protection or Agriculture. The Ministry of Defense was assigned authority to mobilize military units to support rescue operations by local governments. County and city governments, supported by Internal Affairs, assumed responsibility for other tasks related to response, such as certification of the dead and management of dead bodies. Third, the plan also outlines the basic responsibilities for recovery after disaster, but these functions will not be considered in this analysis.

Actions Taken in Response to the ChiChi, Nantou County Earthquake

The conditions in which this earthquake occurred presented a particularly difficult environment for the rapid mobilization of effective response operations. Even with a legal framework for disaster response in effect, the responsible agencies and jurisdictions confronted demands for action which they had not anticipated and for which they had little preparation. Yet, each level of government and each responsible agency acted in response to the urgent needs of the damaged communities within their capacity to do so. A partial record of those actions, constructed from interviews with disaster managers in Taiwan, is listed below. The log of operations reported by this subset of disaster managers provides an informative contrast between the actual demands ensuing from the ChiChi Earthquake and the existing policy framework for disaster management.

Response Operations in Local Jurisdictions: Town and City

Operations Log, 9.21.99

Town of Puli, Nantou County

September 21, 1999:

01:47: EARTHQUAKE!

05:00: Managers are at their sites.

05:30: Volunteer fire sub-teams in town engaged in search-and-rescue operations.
Field operations are in chaos!

September 22, 1999:

08:00: Order gradually returns during the day:

Fire Department, Police Department, Town Government personnel are all engaged in disaster operations; assistance comes from international teams, nonprofit organizations
People need food, shelter; Government distributes supplies

September 27, 1999:

I Guang Doh, Buddhist organization, arrives in Puli to assist people who have lost their homes, and who need food, shelter. The organization's services adapt to meet needs of people as these needs change. Once town residents who suffered losses have basic shelter and food, they need counseling regarding the trauma of their loss and assistance in designing a plan for the future of the community.

Operations Log, 9.21.99

Nantou City, Nantou County

September 21, 1999:

01:47: EARTHQUAKE!

02:00: Residents of city gathered in area of Town Hall

02:05: Mayor calls meeting of Town Rescue Council: each member contacted other members of the Rescue Council, volunteer fire sub-teams and Civil Defense

02:15: City Fire Department established Emergency Operations Center

02:20: Mayor contacts County Magistrate to report status of Nantou City

02:25: Mayor mobilizes all doctors, nurses in Nantou City to respond to medical needs of injured

02:30: First priority was given to search and rescue operations

03:00: Search and rescue operations continued throughout the night and first day; disaster operations continued as people, without homes, seek shelter, food. Nonprofit organizations arrive to give assistance.

12:00: Mayor contacts captains of the 34 li (wards) to assist him in checking on safety, needs of residents of their respective li and to distribute disaster relief in terms of food, clothing, water for those in need. This effort continued throughout the first five days of disaster operations.

September 22, 1999:

12:30: Telephone communications were restored. Disaster operations were facilitated by access to telephone communications. Response efforts focused on mobilization of resources to meet needs of people who suffered damage to their homes and loss of their jobs.

*Operations Log, 9.21.99
Town of Shih Kang, TaiChung County*

September 21:

01:47: EARTHQUAKE!

01:48: Conditions: dark, no electricity, no communications, difficult to see damage.

05:30: Town manager drove through town of Shih Kang on motorcycle to observe the damage.

06:30: Town manager contacted all li captains and asked them to report to Town Hall.

08:00: Town manager met with li captains, asked them to return to their neighborhoods and to conduct a damage assessment and report back to the Town Manager.

13:00: Town manager learned that President Lee was coming to TaiChung County; Feng Yuan.

13:15: Town manager went to TaiChung to see President Lee to tell him about the damage to Shih Kang. Until that time, Shih Kang had received no external assistance, and was struggling with massive destruction and limited capacity to restore the lives of its people.

September 22:

08:00: Japan Red Cross Search and Rescue Team arrived to assist in SAR operations.

10:00: Japanese Medical Team arrived to offer medical assistance, followed by public health experts.

September 23:

09:00: Military units arrive in Shih Kang to assist with disaster operations.

*Operations Log, 9.21.99
Town of Shih Kang, 99th Division, Marines, Military Base, TaiChung County.*

September 23:

09:00: 99th Division of Marines, 1st team, 1 division, arrive in Shih Kang to assist with disaster operations.

Most trapped people were already rescued; most bodies were extricated from rubble.

First task: To move all bodies to County site for identification and burial.

Second task: To set up tent cities for people who needed shelter.

Third task: To inspect damaged buildings for safety, possible repair.

Fourth task: To demolish buildings that were considered unsafe.
Disaster operations continued over next three weeks.

Response Operations at County Jurisdictional Level

Operations Log, 9.21.99

Nantou County Emergency Operations Center.

September 21, 1999

- 01:47: EARTHQUAKE!
- 01:48: Nantou County Fire Chief contacts Magistrate and local military to inform them of severity of the event, using the Fire Administration's radio system
- 01:57: County residents arrive at Magistrate's Office
- 02:07: Magistrate establishes County Emergency Operations Center; many reports of information are coming in simultaneously; people are trapped under collapsed buildings
- 02:08: County Fire Chief activates fifteen fire sub-teams in Nantou County for search and rescue operations, using Fire Administration radio
- 02:10: County Fire sub-teams respond to needs in their respective communities; each has authority to act. If they need assistance, they call the County Fire Chief via radio
- 04:00: Magistrate moves County Emergency Operations Center to gymnasium for more effective disaster operations
- 04:30: Prime minister reaches County Magistrate via military radio; asks local military units to assist Nantou County
- 05:30: Fire sub-teams report status of individual communities back to Magistrate at County Operations Center
- 06:30: Prime minister overflies damaged area in a military helicopter
- 07:00: Prime minister arrives at Nantou County Emergency Operations Center
- 07:10: Prime minister makes an announcement regarding the severity of the disaster, asks assistance of military in region
- 10:00: President Lee arrives at Nantou County Emergency Operations Center; priority is set for search-and-rescue operations
- 10:05: General, commander of 6th Division of Marines from Tainan County, reports to Nantou County Emergency Operations Center, mobilizes all military helicopters in Tainan County to assist with disaster operations in Nantou County
- 10:30: Meeting with all County organizations engaged in disaster response operations
- 12:00: National Fire Administration in Taipei set up a satellite system to communicate via satellite from EOC in Nantou County to Central Government offices in Taipei; telephone communications are restored
- 12:10: National Fire Administration asked Department of Defense to mobilize military assistance
- 14:00: Prime Minister sent Associate Minister of Internal Affairs, Din, to Nantou County Emergency Operations Center to serve as co-director at same level as Magistrate
- 17:10: Japanese SAR team arrived in Taipei, but could not reach area; did not have proper transportation
- 24:00: Pres. Lee and Japanese rescue team arrive in Nantou; needed to repair bridge to reach town

September 22:

01:00: SAR team arrived in ChungHua; found no one alive. Four emergency response personnel in town to conduct SAR operations; 40 volunteers

Response Operations: Joint County and National Jurisdictions

Operations Log, 9.21.99

*Vice Minister, Ministry of Interior, ROC and Member, National Assembly,
TaiChung County Coordinating Office*

01:47 *EARTHQUAKE!*

01:48: Ministry of Interior activates the National Emergency Operations Center (EOC) in Taipei

02:30: Minister Huang, Interior, called a meeting of senior officials with emergency responsibilities: Police Department, Fire Department, staff from other ministries participated..

03:10: Prime Minister arrived at EOC; Vice President & President came to EOC minutes later

03:30: Vice Minister Chien, in Kaohsiung, was asked to report to Nantou County to coordinate response operations with military for search and rescue for Ministry of Interior

08:00: Vice Minister Chien arrives in Nantou County

08:10: Operations were extremely difficult; no electricity, no water, no transportation in Nantou County; helicopters were only means of transportation, communication.

First priority was given to search and rescue operations. Resources of National Government were organized to support SAR. County Emergency Operations Centers were established; all ministries sent representatives to County EOCs to support SAR operations; local military arrived on the 1st day. Searching for victims trapped under the rubble continued, with local people joining the effort to rescue family, friends, and neighbors.

21:00: Vice Minister Chien reports to Ministry of Interior in Taipei on status of search and rescue operations, and requests further assistance.

Operations Log, 9.22.99

Executive Yuan, Central Government's Coordinating Office, Taichung County

September 22:

08:00: Executive Yuan became involved in mobilization of response; provision of national assistance to affected counties. Coordinating offices between national, county and city/town administrations were established in Taichung and Nantou Counties.

September 23:

10:00: President Lee ordered Department of Defense to establish command of disaster operations. Central Government is responsible for damage assessment.

September 24:

08:00: Military regiments from Tainan and other counties in Taiwan arrived in Nantou and Taichung Counties to assist in disaster operations. Military units were assigned responsibility for establishing tent cities for people who had lost homes, assessment of damaged buildings, and debris removal.

Organization of reconstruction process began. Executive Yuan formed 13 different groups; military formed a parallel system, 13 groups;

Executive Yuan dispatched command centers to 18 of the 60 districts in Taiwan, or 30%; 27 out of 309 townships, or 8.7%, in Taiwan were affected by the EQ.

Response Operations at National Jurisdictional Level

Operations Log, 9.21.99,

National Fire Administration, Republic of China, Taipei

September 21:

01:47: EARTHQUAKE!

01:48: Minister of Internal Affairs activated the National Disaster Prevention Center

02:07: National officials with emergency responsibilities arrive at the National Disaster Prevention Center

02:30: Prime Minister arrived at Center

03:10: Vice President arrived at Center; formed an advance team of senior administrative officers and personnel

06:10: Advance team left for Nantou County

09:00: National Defence Council accepts offer of U.S. Search and Rescue Team, and issues a formal request for their assistance.

13:00: National Defence Council asks National Center for Research on Earthquake Engineering to evaluate the performance of search-and-rescue operations.

17:10: Japanese SAR team arrived in Taipei to assist in disaster operations; team engaged in search operations at several sites.

Operations Log, 9.21.99,

Ministry of Foreign Affairs, Republic of China, Taipei

September 21:

01:47: EARTHQUAKE!

07:45: Minister arrives at office, Ministry of Foreign Affairs

09:00: Minister receives first call to offer assistance from Japan; needed to consult with National Emergency Operations Center; also received calls from U.S., Russia, Germany, France, Switzerland.

17:10: Japan SAR team arrives in Taipei; Japan's help is important; it is close geographically. Twenty countries sent teams; there were 41 teams in all: 749 professionals, 99 dogs. Teams came from Israel, Malaysia, Switzerland, Macao. Receiving international assistance was a complex issue. Taiwan is not a member of the UN; it is an observer organization of the Red Cross; it is not a member of the World Health Organization; unique political situation; delay in assistance was caused by political reasons.

Operations Log, 9.21.99
National Center for Research on Earthquake Engineering, SAR Evaluation Team, Taipei

September 21:

17:10: Japan SAR team arrived in Taipei, and was dispatched to Nantou County; their equipment was not as heavy as required for collapsed buildings.

September 22:

08:00: NCREE Evaluation Team members met officials in the National Fire Administration, Taipei, and were briefed on status of SAR operations and arrival of the U.S. SAR Team

08:40: Departed to Ch'ing Ch'uan Kang (CCK) Airport, Taipei

12:00: Waited at CCK

14:30: First group of US SAR team arrived in Taipei

15:05: Met with nineteen members of U.S. Search Team and departed for disaster region.

17:15: Joint US-Taiwan group arrived at Fire Department of YunLin County, and received a briefing on status of damaged buildings:

1. KuanTi building (16 floors) – chosen because of greater probability of finding survivors
2. ChungShan KuoPao building (12 floors)

18:05 Arrived earthquake-damaged KuanTi building scene.

19:10 Set up a temporary on-site rescue command post. –

1. The scene
2. Teachers' study building

19:20: Received report that second group of U.S. team had arrived in Taiwan, and had chosen a base of operations

19:30 Completed the communication means between on site command post and operations base.

19:50 Completed the arrangement of on site-command post and set up the warning system.

20:35 Called the first work coordinating meeting. The meeting ended at 21:10.

21:40 U.S. rescue equipment was delivered to the base of operations.

22:30 Second group of the U.S. rescue team members and their equipment arrived at on-site command post; total U.S. Team: 92 personnel; 4 SAR groups plus management staff.

22:50 Assignments were given in a meeting, and U.S. Search Team asked to move on-site command post for safety reasons. Initial observation equipment was set up.

23:05 Move of the on-site command post was completed, and rescue routes were planned.

23:30 Started rescue operation.

23:40 Made a list of needed rescue materials.

September 23

02:05 Rescued a 32 years old male.

06:05 American Team used supersonic life search machine twice to look for survivors, but it was certain that there was no survivor in the KuanTi building scene.

08:00 Called the first work coordinating meeting, and the main results were the following: (County Fire Chief was the chairman of the meeting)

1. Completed the assignment of rescue operation, and decided to use a helicopter to investigate Puli's damage.

2. U.S. Team and local government should both assign communicating and coordinating staff.
 3. County government decided to appoint the Fire Chief as on site commander and decided to reinforce on site safety operation.
 4. American Team offered rescue and dig technology related staffs to participate in the follow up meetings.
- 09:00: U.S. Team appointed its press person, and asked for a news briefing room. On-site commander assigned county magistrate's house as the place to release the news.
- 14:40: Second joint US-Taiwan SAR operations coordinating meeting; County magistrate chaired the meeting.
1. Reported the results of the helicopter aerial survey conducted in the morning. U.S. Team appreciated the hard work of accompanying staff from Taiwan.
 2. U.S. Team discussed the results of search conducted in the Kuo Pao building that morning. Since they estimated the chance of finding survivors there as minimal and there were frequent aftershocks, U.S. Team decided not to reenter the damaged area.
 3. Reviewed the on-site (in the earthquake-damaged areas) safety situation, especially for calming the family members of victims.
 4. U.S. experts reported that a landslide at upstream ChoShui River had blocked the water flow, and formed a small dam. This situation could be a potential danger, and needs close attention.
 5. Observations and suggestions made by the U.S. Team would be assigned to the relevant ministries for further work.
- 20:10: Third joint US-Taiwan SAR operations coordinating meeting; County magistrate chaired meeting. Issues considered:
1. Search and rescue work done by U.S. Team in YunLin County was appreciated.
 2. Family members of victims used heavy machines to dig in their own houses. U.S. Team considered this action unsafe, and stopped their search and rescue work. Instead, they offered relevant technology to pull down the house, and suggested pulling it down from the top..
 3. Family members of victims insisted on digging on a larger scale. Since the public considered finding bodies as important as saving lives and the top-down way of pulling down the house suggested by U.S. Team required more time and risked the safety of U.S. team members, it was decided that the U.S. Team should stop the operation, but both sides should further discuss the administrative issues.
 4. Participants in the meeting reached consensus, and decided to call a negotiation meeting the next morning. (9/24, 08:00AM)

Operations Log, 9.21.99

Red Cross Organization of Taiwan, National Headquarters, Taipei

September 21:

- 01:47: EARTHQUAKE!
- 01:48: Red Cross staff in Taipei felt the earthquake; tried to call for information; telephones were out; no communication.
- 01:50: Red Cross staff listened to the radio for information.

- 08:00: Red Cross staff contacted available staff at County Red Cross chapters and asked them to contact their local governments for information about damage and needs of people in the communities
- 09:00: Red Cross staff at national level sought volunteers to assist disaster-stricken communities; organization of assistance teams was difficult; depended upon response from chapters.
Task: to solicit donations and to organize volunteers for disaster assistance to stricken communities; work continued through following weeks

Response Operations at International Jurisdictional Level

Operations Log, 9.21.99

American Institute of Taiwan, Taipei

September 21:

- 03:00: Staff at American Institute of Taiwan (AIT) called National Defense Council of Taiwan to offer assistance of a U.S. Search-and-Rescue Team; NDC replied they would check, if needed.
- 07:00: Staff at American Institute of Taiwan (AIT) sought information about the extent of damage from the earthquake; no power, no communication with disaster sites; only at daylight did they get an aerial view of damage
- 08:55: AIT staff went to premier's office to offer assistance of U.S. SAR team
- 09:00: National Defence Council officially requested a U.S. Search and Rescue team to assist with SAR operations
- 10:30: Based on incoming information and aerial views, AIT staff were able to identify sites of heavy damage; directed incoming international teams to those sites. Most rescues were made by local people.
- 11:00: Identified a site in Nantou County for U.S. team's operations; 4 major collapsed buildings; difficult engineering problems; local and National Fire Administration authorities had requested assistance.

September 22:

- 14:30: U.S. SAR Team arrived in Taipei
- 16:30: With Taiwanese police escort, U.S. Team arrived in disaster region

This record of reported actions, while only partial, nonetheless reveals important characteristics regarding the actual function of emergency response operations. First, the most critical actions in terms of saving lives following a severe earthquake are those taken at the local level. Regrettably, this is the level of government that most often has the least preparation, training and equipment to undertake those actions. Though legal responsibility for preparedness is specified in the National Emergency Plan, the local community remains a vulnerable link in the evolution of a national emergency response system, if it does not have the resources or the experience to engage in steps needed for adequate assessment and mitigation of seismic risk. Reports of actions taken by managers from the towns of Puli in Nantou County and Shih Kang in Taichung County illustrate the difficulties in organizing response operations at the local level. Nonetheless, reports from both towns document self organizing behavior on the part of local officials and residents to cope with the extraordinary demands of the disaster.

Second, the National Emergency Plan allocated emergency responsibilities to the respective national ministries and departments that have responsibility for maintaining normal operations in the crucial areas of Transportation, Internal Affairs, Agriculture and National Defense, essentially creating a network of organizations that constitute a disaster response system. Yet, such a network is dependent upon multi-way communication among all participants and a shared base of knowledge about the stricken region, available resources and techniques in order to function effectively under the urgent conditions of disaster. It operates both laterally within jurisdictions and vertically between jurisdictions. Without such communication, the needed coordination among the participating agencies is limited, and agencies struggle with their assigned tasks separately, unable to reach their full potential for multi-agency disaster response.

Third, the development and maintenance of a knowledge base to support interorganizational response to a major disaster requires a substantial investment of time and resources at local and national levels of administration. Although these functions were recognized in the 1994 National Emergency Plan, the actual implementation was not fully in place. Failures in communication, reported by virtually every agency at each jurisdictional level, illustrates the extent to which effective disaster response depends upon a network of actors, and the capacity to share timely, accurate information among them.

The quick response by National Taiwan University to organize and implement a Geographic Information System following the earthquake recognized the need for an advanced information infrastructure in disaster operations, and represents an instance of self organizing behavior to meet this need. The difficulty, however, is that unless the GIS is in place prior to the event, it cannot be used to guide the immediate response. In a complex, multi-site disaster such as the ChiChi Earthquake, a current, functioning GIS would be invaluable in guiding response during the first hours, especially in search-and-rescue operations, where informed action is critical to saving lives.

Fourth, the action log shows that most actions were the product of informed response by responsible agencies to reports of conditions directly from the disaster region, not the result of hierarchical command. The participation by the military was a major exception to this observation, as it responded to President Lee's request, initially, to support local efforts at disaster response, and later, on September 25, 1999, to his declaration of emergency status. Interestingly, the formal declaration of emergency status was apparently done more to facilitate recovery and reconstruction than to assist the response operations, which were largely over by the time of the decree. The action taken by the Town Manager of Shih Kang to drive his motorcycle to Taichung and communicate the needs of his town directly to President was not stipulated in the Emergency Plan, but nonetheless had the beneficial effect of securing Presidential attention to the needs of his community. It was an action taken when the prescribed means of communicating needs was either unavailable or had little effect.

The National Emergency Plan, in its design, represents essentially a vertical coordination of response actions. Yet, the reported actions taken at each level involved, first, lateral coordination, representing in many instances spontaneous efforts at self organization. The dynamic demands of disaster response operations require both vertical and lateral coordination to be effective. Efforts to achieve

administrative control in a complex disaster environment are unlikely to be successful without encouraging and facilitating self organizing processes within the legal framework of response.

Conclusions and Recommendations

Mobilizing interorganizational response to disaster can be achieved most effectively by facilitating processes of self organization and lateral coordination among response organizations within the legal policies of administrative direction and control. This complex set of tasks requires an appropriate information infrastructure to facilitate the search, exchange and feedback of information among the participating response organizations. In many respects, the effort to build such an information infrastructure for disaster management is already underway in Taiwan, led by governmental agencies, research centers and universities, and in cooperation with nonprofit organizations and private companies. The striking cultural openness to new concepts, new methods, and new strategies by which to improve performance, characteristic of Taiwan's people and organizations, will likely prove a major contribution to this process.

I offer five specific recommendations to support the evolution of a dynamic disaster response system. They are:

Conduct a systematic process of after-action review of response operations for this complex event. Informal reviews could be conducted within each organization that had specific responsibilities for disaster response; more formal reviews could be conducted among organizations interacting at the same jurisdictional level – town, county, national. Professional reviews could be conducted by key organizations that hold major responsibilities for response operations across jurisdictional levels, e.g. the Ministry of Internal Affairs, National Fire Administration, Ministry of Health, Ministry of Construction. The benefit of such a review process is to learn from this experience in order to mitigate the continuing problem of seismic risk and other hazards in Taiwan.

Invest in information infrastructure to support communication, coordination among levels of government involved in emergency response: town, county, national, international

Use resources of universities to build a knowledge base for communities vulnerable to seismic and other hazards, as well as to improve training of emergency response personnel
Develop linkages in research and training with other nations exposed to seismic risk, as a means of expanding knowledge and skills in coping with the recurring problem of earthquakes and other hazards in Taiwan

Propose international standards for humanitarian assistance in disaster so that needed assistance will not be delayed or affected by political constraints

ENDNOTES

REFERENCES

- Comfort, Louise K. 1994. "Self Organization in Complex Systems." *Journal of Public Administration Research and Theory*. Vol. 4, No. 3 (July):393-410.
- Comfort, Louise K. 1999. *Shared Risk: Complex Systems in Seismic Response*. Oxford and New York: Pergamon Press.
- Earthquake Engineering Research Institute. 1999. EERI Special Report: *The Chi-Chi, Taiwan Earthquake of September 21, 1999*. December, 1999. The report is published on the EERI Web page: <http://www.eeri.org/Reconn/TaiwanFinal.htm>.
- Fesler, James W. and Donald F. Kettl. 1991. *The Politics of the Administrative Process*. Chatham, NJ: Chatham House.
- Kaufman, Herbert. 1985. *Time, Chance and Organizations: Natural Selection in a Perilous Environment*. Chatham, NJ: Chatham House.
- Kauffman, Stuart A. 1993. *The Origins of Order: Self Organization and Selection in Evolution*. New York: Oxford University Press.
- March, James G. and Herbert A. Simon. 1993. *Organizations*. New York: Wiley. 2nd Ed.
- Ministry of Interior. 1994. *National Emergency Response Plan*. Taipei: Government of Taiwan.
- Research Center for Urban Safety and Security. 1999. *921 Chi-Chi (Taiwan) Earthquake Preliminary Reconnaissance Report*. Kobe, Japan: Kobe University. October 9, 1999.
- Simon, Herbert A. 1981. *The Sciences of the Artificial*. Cambridge, MA: MIT Press.

APPENDIX

Table 1: Assessment Indicators for Disaster Response Systems

Dimensions: I. Technical Structure:

Indicators: High:

- Existence of informed assessment of seismic risk
- Existence of building codes calibrated to seismic risk
- Existence of requirements for soils analysis and engineering surveys prior to construction of new buildings, transportation
- Existence of alternative communications capabilities in event of earthquake
- Existence of special Emergency Operations Centers and equipment for disaster response
- Identification of major facilities in community that are vulnerable to seismic risk

Medium:

- Historic record of seismic events and their effects on technical structures
- Some seismic design features included in construction, such as steel rebar reinforcements, ceiling to wall connectors
- Existence of equipment and operations centers for emergency services: police, fire, emergency medical corps
- Existence of basic communications capacity among local organizations during normal operations
- Identification of possible sources of risk and assistance in seismic events

Low:

- Little to no assessment of risk to community from possible seismic event
- Little to no change in building construction due to previous seismic events
- Little to no investment in emergency preparedness at the local level
- Little to no anticipation of future seismic events

II. Organizational Flexibility

High:

- Existence of a national law establishing legal authority for emergency response
- Existence of a disaster response plan that integrates capacity from several jurisdictional levels to meet the needs of an earthquake-damaged community
- Existence of an interdisciplinary, interorganizational, interjurisdictional knowledge base for seismic risk, response, and possible consequences for the community
- Existence of multiway patterns of information exchange within and between organizations and jurisdictions that participate in emergency response
- Existence of trained, professional managers with the experience and authority to adapt existing administrative plans to the demands of the event
- Existence of trained reserve personnel available on recall in disaster events

Medium:

- Existence of a national law that establishes authority for disaster response
- Existence of general training programs for public agencies in disaster response
- Existence of disciplinary knowledge bases within specific organizations regarding

possible consequences and criteria for action in disaster
Presence of professional staff able to take innovative action under urgent conditions
Capacity to establish communications patterns with 'feedback loops' with new organizations

Low:

Little or no national authority for disaster response
Little or no training or preparedness for disaster response
Little or no common knowledge regarding the risk, possible consequences, or criteria for action for seismic events
Little or no professional staff with authority to act in emergency conditions
Little or no communication within or between organizations and jurisdictions regarding seismic risk

III. Cultural Values

High

Shared values regarding humanitarian assistance to those in need
Commitment to goal of protecting life and property for all members of community
Ready acceptance of new information from valid sources
Openness to new methods of working and acting with other organizations and jurisdictions in order to achieve a shared goal
Information exchange between organizations and between jurisdictions
Willingness to review actions taken and to correct mistakes discovered between organizational and/or jurisdictional working groups
Continual search for relevant, accurate, timely, information to protect community

Medium:

Shared values regarding loyalty to organization, profession
Information exchange within organizations and within jurisdictions
Willingness to review actions taken and to correct mistakes discovered within organizational and/or jurisdictional working groups
Willingness to consider alternative modes of problem solving and action within organization or working groups
Reliance upon historical information to inform decisions regarding protection of community

Low:

Little to no value placed upon public and/or community interest
Little to no shared knowledge regarding risk or resources among organizations, jurisdictions, or citizens
Little to no information search or exchange among organizations and jurisdictions
Little to no trust or experience in solving common problems among organizations, jurisdictions, or citizens
Little to no willingness to review actions taken or to correct mistakes for future

Source: Louise K. Comfort. 1999. *Shared Risk: Complex Systems in Seismic Response*. Oxford and New York: Pergamon Press:65-66.

1. I am grateful to the Research Center for Urban Safety and Security (RCUSS), Kobe University, for including me as a member of its interdisciplinary Reconnaissance Team that visited Taiwan following the 9.21.99 ChiChi Earthquake. This account is based upon professional observations of the disaster sites and interviews with disaster managers conducted during the period of this study, October 2-10, 1999.
2. I thank Jenny Hsu, Graduate School of Business Administration, Kobe University, for her translation of the National Emergency Response Plan of Taiwan and other government reports from the original Chinese to English.
3. I acknowledge, with thanks and appreciation, Professors Jay Shih and Chung-Yuang Jan, Department of Public Administration, National ChengChi University, Taipei, and Kai-Hung Fang, Legislative Aide to Legislator Ming-Hsiung Chang, Nantou County, Government of Taiwan, Taipei, for their thoughtful assistance in arranging interviews and translation in the conduct of this study.
4. These measurements of the earthquake were presented in a briefing on the 9.21.99 ChiChi Earthquake given by Dr. Chin-Hsiung Loh, Director, National Center for Earthquake Engineering Research, Taipei, Taiwan, October 3, 1999.
5. These statistics were reported by the Taiwan Ministry of Interior, October 21, 1999, as cited in the EERI Special Report: *The Chi-Chi, Taiwan Earthquake of September 21, 1999*. December, 1999. The report is published on the EERI Web page:
<http://www.eeri.org/Reconn/TaiwanFinal.htm>.
6. On-site observations in Feng Yuan, Teng Shih, Shih Kang, Nantou City, ChungHua, and Puli, Taiwan, October 3 - 6, 1999; professional report by I. Mitani and A. Tani, "921 Chi-Chi (Taiwan) Earthquake," Preliminary Reconnaissance Report, Research Center for Urban Safety and Security, Kobe University, Kobe, Japan, October 9, 1999.
7. Briefing on 921 ChiChi Earthquake by J.C. H.Lin, Director of National Science & Technology Program for Hazard Mitigation, National Taiwan University, Taipei, Taiwan, October 2, 1999, 4:30 p.m.
8. The building design code for Taiwan has been changed three time in recent years. The original building code was developed over the years, 1974 - 1982. In the years, 1982 - 1987, the code was revised to raise the coefficient for strength of buildings. In the years, 1987 - 1997, the code requirements were raised again. The latest code requirements were in effect at the time of the 9.21.99 Earthquake. Briefing, Dr. Chin-Hsiung Loh, Director, National Center for Research on Earthquake Engineering, National Taiwan University, Taipei, Taiwan, October 3, 1999. The 1996 date was cited in the EERI Special Report, p. 3, 1.
9. Interview, Chung Chi Lin, Chief, Fire Administration, Nantou County, Nantou, Taiwan, October 4, 1999.

10. Briefing on 921ChiChi Earthquake, J.C.H. Lin, Director, National Science & Technology Program for Hazard Mitigation, National Taiwan University, Taipei, Taiwan, October 2, 1999.

11. Yeh, Wei-Chuan. Director, Department of Overall Planning, Research, Development & Evaluation Commission, Executive Yuan. Taichung, Taiwan, October 6, 1999, 9:30 a.m.

12. Interview, Webster Kiang, Vice Chairman, Research, Development & Evaluation Commission, Executive Yuan, Taichung, Taiwan, October 6, 1999, 11:00 a.m.

13. National Emergency Plan for Natural Disaster. *1994*. Government of Taiwan, Taipei, Taiwan. I acknowledge the National Fire Administration, Taipei, for giving me a copy of this plan on October 7, 1999.