Enhancing communication among emergency responders by developing exercise programs in Vietnam

A Thesis for Acquirement of the Degree of Doctor of Engineering

Course of Environment and Resources Systems
Graduate Programs in Environmental Systems,
Graduate School of Environmental Engineering,
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Kitakyushu, September 2019

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LIST OF ABBREVIATIONS

AHP	Analytic Hierarchy Process
ANOVA	One-way analysis of variance
CEM	Center for Environmental Monitoring
CNDPC&SR	Committee for natural disaster prevention and control and search and rescue
CR	Consistency Ratio
CSCNDPC	Central Steering Committee for Natural Disaster Prevention and Control
DARD	Department of Agriculture and Rural Development
DMOC	Disaster Medical Operation Center
DONRE	Department of Natural Resources and Environment
EEG	Exercise Evaluation Guides
EIA	Emergency Impact Assessment
EMP	Emergency Medical Plan
EOC	Emergency Operation Center
FEMA	Federal Emergency Management Agency
FFPD	Firefighting Police Division
FX	Functional exercise
HFA	Hyogo Framework of Action
HHP	Haiphong Port
HSEEP	Homeland Security Exercise and Evaluation Program
HTA	Hierarchical task analysis
ISO	International Standard Organization
JICA	Japan International Co-operation Agency
JMAT	Japan Medical Association Team
KFEX	Kitakyushu functional exercise
KMA	Kitakyushu Medical Association
LMA	Local Medical Association

MARD	Ministry of Agriculture and Rural Development
NIMS	National Incident Management System
OECD	The Organisation for Economic Co-operation and Development
PCs	People’s Committees
SFDRR	Sendai Framework for Disaster Risk Reduction
SID	Sea and Islands Division
SNA	Social Network Analysis
TTX	Table-top exercise
UNISDR	United Nations International Strategy for Disaster Reduction
VINASARCOM	National Committee for Incident and Disaster Response and Search and Rescue
WAMM	Weighted arithmetic mean
WHO	World Health Organization

1. INTRODUCTION

1.1. Background

An emergency is defined as an exceptional event that exceeds the capacity of normal resources and organization to cope with it (Alexander, 2002, p. 1). Along with history, human beings have had to face various types of emergencies (Canton, 2007). These events affect both organizations and communities and are generated from either nature; such as earthquakes, typhoons, and floods; or man-made; such as fires, oil spills, and terrorism. In case of overall impact of hazardous conditions in these events higher than safety level of organizations and communities, it becomes a disaster with specific consequences. In the context of climate change, deforestation and industrialization, emergency events are becoming more complex. Therefore, there is high demand to enhance levels of safety for organizations, including enhanced resistance and resilience capacities for the emergencies.

Emergency responders are key individuals who respond to emergencies and minimize damage and losses. They are expected to be quick and efficient when responding to an emergency but are often faced with abnormal conditions such as inadequate information, lack of time, stress, or simply the dynamic nature of the emergency (Brehmer, 1996; Flin, 1996). In many situations, emergency responders work in groups and teams. These teams are formed based on different roles and functions, in which they work together during an emergency. Therefore, to effectively respond to the emergency, it is imperative that response teams cooperate and communicate between each other. In fact, responders require a comprehensive understanding of different sectors regarding roles, responsibilities and authorities (McKing, 2010; Perry & Lindell, 2003; Prizzia, 2008). This teamwork allows responders to understand the roles of others, minimize duplication of actions, and facilitate efficient communication.

To enhance the capability of emergency response organizations, exercise programs are designed to train responders, as well as evaluate core capabilities within emergency tasks. Emergency exercises are a key component for an effective emergency preparedness program while also providing unique insight for the preparedness of emergency response organizations (International Atomic Energy Agency (IAEA), 2005). Training and exercises help participants improve readiness for emergency response through facilitating plans and operations, reinforcing teamwork, and demonstrating a community's determination to prepare for incidents. Improve communications among responders is a key benefit of implementing exercises into an emergency management program (Canton, 2007, p. 119; Phelps, 2011). Other benefits of exercises include clarifying roles and responsibilities, find resource gaps, develop individual or group performance, and identifying opportunities for improvement as documents of Federal Emergency Management Agency (*IS-120.A: An Introduction to Exercises*, 2008). Therefore, efforts for making better exercise programs are necessary for all emergency management organizations.

Vietnam, a developing country in Southeast Asia, is highly exposed to a wide variety of hazards, with more than 70 percent of the population exposed to disasters (Chau, Holland, & Cassells, 2014; *Vietnam Disaster Management Reference Handbook*, 2018). The country has been described as having a long "S" shaped figure, with a vertical coastline of 3,260 km (*Vietnam Disaster Management Reference Handbook*, 2018) and an estimated population of 95,261,021 as of July 2016 ("The World Factbook Vietnam," n.d.). As one of the most active developing countries in Southeast Asia, Vietnam is faced with a higher risk of man-made hazards such as fires and transportation incidents. Moreover, climate change has led to an ongoing rise in the sea level and an increase in the occurrence of extreme weather events. Enhancing the capability of emergency response systems is an important issue not only in Vietnam but also in other countries under light of the Hyogo Framework of Action 2005 to 2015 (UNISDR, 2005) and the Sendai Framework for Disaster Risk Reduction 2015–2030 (UNISDR, 2015) published by the United Nations International Strategy for Disaster Reduction (UNISDR).

The main purpose of this research is to develop exercise programs that are focused on enhancing the communication of emergency responders in Vietnam. Currently, there are various types of emergency exercises including seminars, workshops, table-top exercises, drills, functional exercises and full-scale exercises. Among these exercise types, table-top exercises (TTX) and functional exercises (FX) are the most popular for encouraging communication among exercise participants. Basic TTX seek to solve problems in a group-setting by discussion and brainstorming (Phelps, 2011). In a FX, a series of simulated emergency events, or "exercise injects", are provided to exercise participants, or “players”, as they find solutions together to the problems specified in those injects. FX is more realistic than TTX, but requires advanced levels of exercise design and preparation. This research targets to improve the benefits of doing TTX and FX for emergency responders in Vietnam.

1.2. Problem statement

There are demands for studies about emergency management systems in developing countries (Rodríguez, Quarantelli, & Dynes, 2007, p. 167). Reviewing records of policy development in emergency management supports both organizational and individual capability building (Chau et al., 2014). However, each nation has its own system to manage and respond to emergencies that reflect the characteristics of that nation’s government, economy, and culture. In Vietnam, existing international studies of Vietnamese emergency management (Chau et al., 2014; Garschagen, 2016; Lebel et al., 2009) focus on the specific organizational structures of natural disaster risk management or flood management. There are a lack of publications that review Vietnamese emergency management that specify related organizations in charge of responding in natural and man-made disasters. Moreover, Katarzyna in the research “Emergency Coordination Framework in Vietnam” (2001) stressed that there is a need to improve the communication, coordination, and cooperation of different Vietnamese stakeholders during a disaster. Therefore, it is necessary to review the characteristics, development of policy, and institutional structures of emergency response in Vietnam.

Exercises are a key component within an emergency management program. To better understand the role of exercises, the Homeland Security Exercise and Evaluation Program (HSEEP, 2013) was published by the Department of Homeland Security in the United States of America. This document provides a set of guiding principles for an exercise program. The HSEEP exercise cycle specifies four elements, which include Exercise Design, Conduct, Evaluation, and Improvement Planning. This cycle is similar to the continuous improvement cycle (PDCA cycle), that emphasizes improvements after evaluating results of any program. In the thesis, we focus of developing suitable exercise design and evaluation programs for both TTX and FX to enhance communications among emergency responders.

Exercise design establishes a base for an exercise. Many key issues need to be defined during the exercise design process, including need assessment, exercise scope, and exercise type (*IS-139.A: Exercise Design and Development*, n.d.). In need assessment for emergency exercise, the first step is to identify hazards related to practical conditions of organizations, communities. Hazard identification is considered as an essential and fundamental step to successfully designing exercises. After hazard identification, an exercise planning team need to choose exercise topic and scope (HSEEP, 2013). Meanwhile, for exercises with participants from different stakeholders, the exercise planning team is established by gathering leaders or experts from different subject areas to determine the base for the exercise. However, it is necessary to have an approach to combine opinions of different members within the planning team to select appropriate the exercise topic. Moreover, it becomes more challenges for the exercise planning team when they plan to conduct a new type of emergency exercise, as well as involve participants from various organizations. Therefore, it is necessary to develop an approach to combine the opinions of members in the exercise planning teams to choose appropriate topics for emergency exercises.

There is room for improvement for TTX and FX evaluation methods. The objectives of an evaluation program are interconnected with the exercise objectives. In particular, a TTX is the most common discussion-based exercise, and encourages discussions and share common understanding among participants (Canton, 2007). A TTX is targeted to provide a stress-free discussion environment for participants without actual operations. Therefore, it is important to observe a TTX to discover key supporting information to then share and discuss among various stakeholders as good evaluation program. More complicated than a TTX, a FX is an operation-based exercise that helps to test communication issues among different groups. The Exercise Evaluation Guides (EEG) within HSEEP (2013) provide a format for rating the achievements of exercise participants. Within the EEG, capability target and critical tasks need to be defined for each organization. Evaluators observe participant's performances and rate their achievements into a target rating system. Another evaluation tool for exercises is the Harvard School of Public Health Exercise Evaluation Toolkit (HSPH, 2013). This toolkit is a combination of a checklist of actions, subjective scoring system and subjective comments field (HSPH, 2013). These above tools use qualitative approaches that are in form of checklist, in which experts review and comments during an exercise. Therefore, results of exercise evaluation might vary considerably depending on the skills of the evaluators. It is necessary to develop quantitative or standardized approaches for gathering data rather than narrative in form (Savoia, Agboola, & Biddinger, 2014). Another researchers, Nelson, Lurie, & Wasserman (2007) declared that there is a lack of metrics involving time-based attributes to observe and evaluate exercises. Therefore, there is a lot of potential for studies on using a time element to evaluate participant's performance during a FX.

Although TTX and FX are common training activities for emergency responders in developed countries such as the United States of America, Canada, and Japan, there are only a few examples of these exercises being used in developing countries. In Vietnam, information, knowledge and publications about TTX and FX are still limited.

From the problem statement, these research questions are considered in the thesis:

1. What are characteristics of the emergency response system in Vietnam?
2. How to develop an approach for choosing appropriate topics for emergency exercises?
3. How to develop an approach for collecting and using data from TTX?
4. How time elements can be applied for evaluation methods in FX?

1.3. Research objectives

The objectives for this research are as follows:

1. To review characteristics and development of policy and institutional structures of emergency response system in Vietnam.
2. To develop an approach for choosing topics for emergency exercises.
3. To develop methods to collect and extract data from TTX for identifying communication structures among stakeholders.
4. To develop a statistical use of time for a FX evaluation program.

1.4. Research structure

To achieve the main purpose and objectives, the research was conducted as follows:

In Chapter 2, we started from objective 1 to capture the general picture about emergency response system in Vietnam. I focused on identifying the main legal documents and organizations involved in the system, as well as how exercise programs are required in policy of Vietnam. By considering the concept of the international standard ISO 22320 (2011) on requirements for incident response, the Vietnamese emergency response structure was reviewed on the following three functions: command and control, operational information, and coordination and cooperation.

Objective 2 pertains to the area of exercise designs that is to propose procedures to choose exercise topics in emergency fields at port areas in Haiphong city. Two emergency fields are environmental and fire emergency are focused in Chapter 3.

Objective 3 and objective 4 pertain to exercise evaluation for TTX and FX. Chapter 4 is designed to achieve objective 3 of the thesis for data collection and analysis from TTX to understand about communication structures of stakeholders. I proposed methods to collect data in TTX for specific situations, then applied data collection methods in two case studies. For case study 1, sensing interview and questioning technique were used to collect information from environmental experts. Meanwhile, complete observation, verbal protocol analysis and social network analysis techniques were applied for extracting and analysing information of TTX for firefighting and rescue issues. Objective 4 of the thesis is to extract data sources from functional exercises in both Japan and Vietnam. In Japan, time data from three functional exercises related to public health disaster preparedness in Kitakyushu, Japan were collected and quantitative analysed. In Vietnam, one functional exercise for firefighting police were conducted that were observed by time measurement as first time in Vietnam. Data from the functional exercises was quantitatively analysed to find clues for emergency managers.

Research structure for the thesis is shown in Figure 1-1.

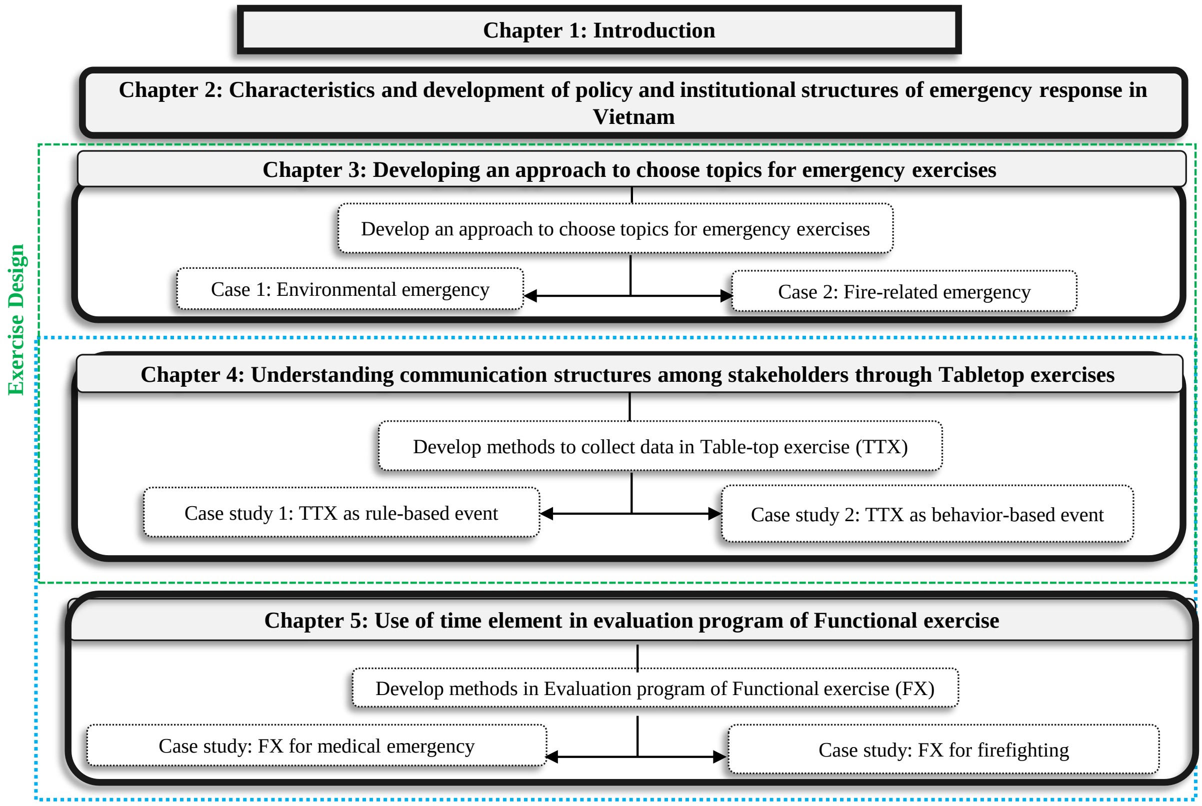


Figure 1-1. Research structure

1.5. Definition of terms

1.5.1. Disaster management and Emergency management

Disaster management is defined by the United Nations Office for Disaster Risk Reduction (UNISDR) as "the organization, planning and application of measures preparing for, responding to and recovering from disasters" in the report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction (2016). Emergency management on the other hand is defined as "short-term measures taken to respond to particular hazards, risks or disaster" (Alexander, 2002, p. 309) and sometimes might be interchangeable with the term disaster management. According to the International Standards Organization in ISO 22320 (2011), emergency management is represented by a set of measures that aim to prevent and manage a disaster or a disruptive event before, during, and after its occurrence. The Federal Emergency Management Agency (FEMA) of the United States of America defines emergency management as "a process through which the Nation prepares for emergencies and disasters, mitigates their effects, and responds to and recovers from them." (ISO 22320, 2011, p. 57) Since several of the concepts and ideas from ISO and FEMA are referred to in our study, we use definitions of emergency management as they are specified by these organizations. In this sense, the definitions of emergency management and disaster management are interchangeable and include the four phases of mitigation, preparedness, response, and recovery from disasters.

1.5.2. Other key definitions

These definitions are according to the International Organization for Standardization, ISO 22300, *Societal Security -Terminology*, 2012.

- Disaster: situation where widespread human, material, economic or environmental losses have occurred which exceeded the ability of the affected organization, community or society to respond and recover using its own resources.
- Hazard: source of potential harm or can be a risk source.
- Incident: situation that might be, or could lead to, a disruption, loss, emergency or crisis.
- Scenario: pre-planned storyline that drives an exercise; the stimuli used to achieve exercise objectives.
- Inject: scripted piece of information inserted into the exercise and designed to elicit a response or decision and facilitate the flow of the exercise.

These definitions are according to the Glossary of FEMA training:

- Communication: A section of the basic plan that refers to the internal and external strategies and tools to communicate with stakeholders in the event of an emergency or incident.
- Coordinate: To advance an analysis and exchange of information systematically among principals who have or may have a need to know certain information to carry out specific incident management responsibilities.
- Exercise: An instrument to train for, assess, practice, and improve performance in prevention, protection, response, and recovery capabilities in a risk-free environment. Exercises can be used for: testing and validating policies, plans, procedures, training, equipment, and inter-agency agreements; clarifying and training personnel in roles and responsibilities; improving interagency coordination and communications; identifying gaps in resources; improving individual performance; and identifying opportunities for improvement.
- Drill: A type of operations-based exercise that is a coordinated, supervised activity usually employed to test a single specific operation or function in a single agency. Drills

are commonly used to provide training on new equipment, develop or test new policies or procedures, or practice and maintain current skills.

- Tabletop Exercise (TTX): A discussion-based exercise intended to stimulate discussion of various issues regarding a hypothetical situation. TTX can be used to assess plans, policies, and procedures or to assess types of systems needed to guide the prevention of, response to, or recovery from a defined incident.
- Functional Exercise (FX): A single- or multi-agency operations-based exercise designed to evaluate capabilities and multiple functions using a simulated response. Characteristics of a functional exercise include simulated deployment of resources and personnel, rapid problem solving, and a highly stressful environment.

2. CHARACTERISTICS AND DEVELOPMENT OF POLICY AND INSTITUTIONAL STRUCTURES OF EMERGENCY RESPONSE IN VIETNAM

2.1. Introduction

It is necessary to understand characteristics of Vietnamese emergency response system before detailed discussion on emergency exercise programs. As one of developing countries, more studies need to be conducted on legislation and government arrangements (Rodríguez et al., 2007). There are several benefits of reviewing legislation and governmental structures related to emergency management. Reviewing records of policy development in emergency management supports both organizational and individual capability building (Chau et al., 2014). Moreover, a review perspective of institutional structures and legal history is an approach that is used to examine the advancement of policy and organizations (Amenta, 2009; Institutions For Floods In Asia, 2005). With the expansion of the occurrence of catastrophic events around the world, there has been a need to review administration strategies to manage these events (Lin, Chang, Tan, Lee, & Chiu, 2011). The Hyogo Framework of Action 2005 to 2015 (HFA) (UNISDR, 2005) and the Sendai Framework for Disaster Risk Reduction 2015–2030 (SFDRR) (UNISDR, 2015) are the two most recent international frameworks for disaster risk reduction. In the Priorities for Action of these international frameworks, the need to enhance disaster management capacities including policy, technical, and institutional capacities are mentioned. More specifically, a guide by the UNISDR for the implementation of the HFA in "words into action" specifies that legislative and governmental systems are important prerequisites for emergency management. Therefore, we aimed to review updated information on legislation, organizations involved in Vietnamese emergency management.

Three specific objectives of the chapter on Vietnamese emergency management are focused according three international initiatives. First, it is encouraged to enhance governments' capacities including legislation and governmental structure in order to manage different types of hazards, and doing different types of exercise. The "multi-hazard approach" is mentioned in both the crosscutting issues of the HFA (UNISDR, 2005) and in the Principles in the SFDRR (UNISDR, 2015). The approach encourages the development of legislation to address different type of hazards. According to UNISDR Terminology (UNISDR, 2016, p. 18), hazards include "biological, environmental, geological, hydrometeorological and technological processes and phenomena." Second initiative is concern on doing table-top and functional exercise for emergency responders to enhance communications. These types of exercise are common in exercise programs of Federal Emergency Management Agency (FEMA) in the United State other than drills. Recently, there also has been developing numbers of Table-top and functional exercises for responders in Japan. The third initiative is an international trend to standardize the emergency response structures of organizations and agencies to overcome barriers among stakeholders in terms of culture and politics (Rodríguez et al., 2007). Currently, standards for emergency response structures exist in some nations and international organizations. For example, the United States Department of Homeland Security provides the National Incident Management System (NIMS, 2008) as a standardized approach for incident management that is intended to be used by the whole community in the United States of America. NIMS is based on three key organizational systems: the incident command system, the multiagency coordination system, and the public information system (NIMS, 2008). The system is an organizational scheme or structure that is used to respond to incidents. The World Health Organization (WHO) provides six primary incident management system functions in their Emergency Response Framework (*ERF)*, 2017, p. 34). The ISO 22320 (2011), which was released by the Technical Committee ISO for Societal Security - Emergency Management - Requirements for Incident Response, provides guidelines for considering command and control, operational information, cooperation, and coordination within an incident response organization. The term "incident" is defined in ISO 22300 for Societal Security - Terminology, 2012) as a situation that could lead to a disruption, loss, emergency, or crisis. An incident includes major disasters and other types of emergency events from both natural and man-made sources that require a response to protect life or property (*NIMS*, 2008).

The first objective is related to the "multi-hazard approach" to review policy of Vietnamese emergency management, governmental structure in different types of emergencies/incidents. Some international studies on the subject of Vietnamese emergency management have been published, including Lebel L. et al. (2009), Garschagen (2016), and Chau V. N. et al (2014). These works provide an introduction and discussion on the specific organizational structures of natural disaster risk management or flood management in Vietnam. Another study by Katarzyna in the research "Emergency Coordination Framework in Vietnam" (2001) focused on the networks between donors and government organizations in the Vietnamese emergency coordination framework. However, Katarzyna's work does not mention connection of legal documents between man-made and natural disaster management and the recently updated improvement of Vietnamese policy. Therefore, we would like to find the development of legal documents and governmental structure to manage both man-made and natural disasters. Second objective is to review key legal documents that mention type and frequency of exercise programs under requirements of Vietnam policy. Third objective, we focus on examining the Vietnamese emergency response structure to natural disasters in light of an international standard. This is our motivation because discussing comparative perspectives among emergency management response systems (McEntire et al., 2009) contributes to facilitating joint disaster operations and cooperation among nations. Natural disaster policy in Vietnam has a long history of development but lack of studies consider the current response system with respect to those standards. Even though we respect the differences in emergency response systems among different nations (Rodríguez et al., 2007), we also believe that international standards provide the possibility of improving emergency response structures in a variety of nations, including Vietnam, by drawing on international perspectives. The ISO 22320, is an international framework that is flexible and can be applied to different types of organizations and agencies in charge of preparing for or responding to incidents (*ISO 22320*, 2011). ISO 22320 is used to consider how the structure of Vietnamese emergency response to natural disasters looks like.

The next sections of the chapter are organized as follows. In Section 2, we present the method that we follow to review and discuss the Vietnamese emergency management system. Section 3 firstly provides overview and records of emergencies in Vietnam. After that, results for three research objectives are provided that include key legal documents and governmental structure, exercise programs, and the institutional structure of Vietnamese emergency response to natural disasters according to the ISO 22320 standard. Moreover, information related to the motto "four on-the-spot" in Vietnam help readers better understand about the country system. The final section draws conclusions and summary key issues related to communication in Vietnamese emergency response system. Most of the information to be described in this chapter was published as To and Kato (2018).

2.2. Methodology

2.2.1. Research approach

To review and discuss the Vietnamese legislation and structure, we applied a systematic review since this method is best suited to focused topics (Collins & Fauser, 2005). A literature review of prior research and official documents is mentioned as an approach by McEntire (2007) to provide a better understanding of emergency management in a nation. Following this approach, a number of reviews on emergency management were conducted in nations that published as training materials the Higher Education Program of FEMA. Our study mainly consists of reviews and discussions of the text of Vietnamese legal documents against our given research questions. To address the first research question, we reviewed legal documents enacted by the Vietnamese government in emergency management to show the reformed policies that cover both natural and man-made disasters. I focused on the development of legal documents that consider different types of disasters, and requirements of exercise programs in Vietnam. The second research question was addressed by reviewing the contents of the ISO 22320 and Vietnamese legal documents on natural disaster response. I discussed the regulations related to the Vietnamese natural disaster response system according to three functions in the ISO 22320, including command and control, operational information, and cooperation and coordination.

2.2.2. Data collection

Through a desk survey of the laws from the Vietnamese Government's legal documents database of Vietnamese Ministry of Justice, we collected the main documents on both natural and man-made disasters. Vietnam's legal system references the French civil law system. According to the Law on the Promulgation of Legal Documents (*No 80/2015/QH13*, 2015), Vietnam's legal documents are divided into laws/ordinances and secondary regulations. Laws and ordinances are legal documents passed by the National Assembly, the highest constitutional body of the Socialist Republic of Vietnam. Secondary regulations are issued by state organizations as legal documents of a lower rank than laws/regulations. In first stage of the online survey, we chose natural disaster and man-made disaster as keywords to collect the relevant laws and ordinances passed by the Vietnamese National Assembly. Since some Vietnamese legal documents are not available in English, we conducted our surveys in both Vietnamese and English. At this stage, eleven laws and ordinances in emergency management were defined as our primary legal documents. By reviewing the contents of these documents, the second stage of the survey was defined, and twenty secondary legislations such as decrees, decisions, and national strategies passed by the government and other competent bodies were identified. The focus of such reviews was to understand the existing Vietnamese legislation and the institutional arrangement in managing both natural and man-made disasters. Moreover, the government structure and the role of organizations at the local level were determined with the person in charge in Haiphong city, the third largest city in Vietnam. I visited the Standing Office of Disaster Prevention and Control in March 2017 to consult the institutional arrangement on the provincial, district, and commune levels. At the same time, we collect the natural disaster management plans for the period 2016–2020 for Haiphong city to better understand the roles of organizations.

2.3. Results

2.3.1. Emergency management in Vietnam

2.3.1.1. Country overview

Vietnam is bordered by China to the North, the Lao People's Democratic Republic to the Northwest, and Cambodia to the Southwest. The Eastern coast of Vietnam is the Gulf of Tonkin and the South China Sea. Vietnam has three main regions, North, Central, and South, and eight sub regions: Northeast, Northwest, Red River Delta, North Central Coast, South Central Coast, Central Highlands, Southeast, and the

Mekong River Delta (Figure 2-1). Each region has different geographic and economic features. Vietnam has low, flat delta terrain in the South and North. The Northwest and Central Highlands are dominated by hilly and mountainous areas (“The World Factbook Vietnam,” n.d.). Vietnam covers 2860 small and large rivers with a total flow of around 867 billion m^3/year ("National report on disaster reduction in Vietnam", 2004) . There are two main river systems in the country: the Red River in the North and the Mekong River in the South.

Vietnam belongs to a tropical monsoon region that has been divided into two different climate zones, a Northern and a Southern zone. The Southern provinces have two seasons: a hot and rainy season from May to October, and a cold and dry season from November to April. The Northern region has four seasons: spring, summer, autumn, and winter. The annual rainfall ranges from 120 cm to 300 cm, depending on the region (Global Security, n.d.).

2.3.1.2. Record of Emergencies

a, Hazards affecting Vietnam

Vietnam faces the risk of different types of potential emergencies, both natural and man-made. Located along the country’s coastline, the Northern and Central coasts are sub-regions that are strongly affected by typhoons from the Northwest Pacific Ocean, which are followed by floods and strong winds. Even Southern Vietnam suffers from a noticeable and non-negligible number of typhoons (Takagi et al., 2015). Typhoons normally affect Vietnam in the period from July to December. In the first stage of typhoon season, typhoons are more likely to affect Northern Vietnam, and they are more likely to affect its Central and Southern regions in the later stages. The average number of typhoons per year in Vietnam is about 12. Lately, due to climate change, the duration of the typhoon season has been longer than in the past and has more seriously affected the Southern areas (Nguyen et al., 2017). Due to the long coastline, typhoons and tropical depressions often result in significant damage to people and properties on a large scale and have an adverse impact on the social-economic activities and dwellings in the affected areas (Ngu. D & Hieu. T, 2004).

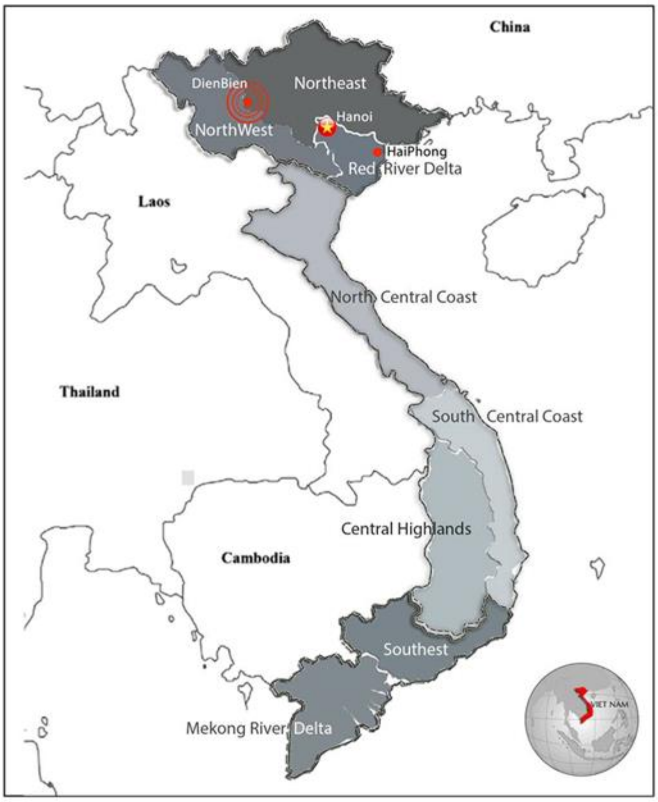


Figure 2-1. The eight sub-regions of Vietnam

Vietnam's mountainous regions include highlands in its Northwest and Central Highlands where there are narrow and steep river systems that are at high risk of flash floods and landslides. In the rainy season, high levels of water overflow riverbanks and then spread to low-lying regions, provoking floods downstream. Other hazards are salt-water intrusions and droughts. As a consequence of the rising sea level and the lack of water in the upstream areas, saline water is penetrating deeper inland in the downstream areas of the Red River and the Mekong River Basin. Close to two million people in Vietnam were affected by the 2015–2016 drought and saltwater intrusion event, which resulted in food insecurity, loss of livestock, and health problems due to water scarcity (Baca et al., 2017).

Although floods, typhoons, landslides, droughts, and salinity are perceived as major natural hazards in Vietnam, the country is also at risk of damage from earthquakes. There are three recorded cases of earthquakes in Vietnam, most of which occurred in the Northwestern region. The highest recorded earthquake on the Richter magnitude scale was 6.8 in Dienbien province in 1983 (Ngo, Nguyen, & Nguyen, 2008). Therefore, it may be said that Vietnam is not safe from earthquakes and that the country faces the risk of seismic disasters.

Furthermore, there are various types of man-made hazards in Vietnam, including urban fires, industrial zone fires, and environmental and traffic accidents. The ongoing development of industrial zones and residential areas with a lack of control, equipment, and awareness of fire protection will create significant risks for fires and explosion accidents. Increasing industrialization activities also increase the cost of man-made disasters (Tansel, 1995).

b, Vulnerability in Vietnam

Vulnerability refers to the propensity of exposed elements such as human beings, their livelihoods, and assets to suffer from adverse effects due to hazardous events (Field, Barros, Stocker, & Dahe, 2012). Vulnerability is dependent on the socio-economic development status in a particular period of time, especially in countries that are undergoing several changes such as economic transformation, rapid growth, urbanization, and social changes (Benson & Clay, 2004). As Vietnam is now one of the most active developing countries in Southeast Asia ("Vietnam Overview," n.d.), it is significantly more exposed than developed countries. In addition, Vietnam is one of the most affected countries by the dint of disasters in the Asia-Pacific region, ranking sixth amongst the world's most vulnerable countries with respect to disasters (*Environmental risks: Understanding the impact of natural disasters: Exposure to direct damages across countries*, 2016). More than 70% of Vietnam's population is threatened by natural hazards, and has a high risk of isolation, especially in rural and low-income regions ("Disaster-Proofing the Transport Sector in Vietnam," n.d.). In the context of climate change, a report from the Japanese Innovative Program of Climate Change Project for the 21st century predicts an increase in the number of intense tropical cyclones in the South China Sea (Kakushin, 2013). The two biggest cities in Vietnam, Hanoi and Hochiminh city, are located on the banks of the Red River and the Mekong River, respectively, and will be dramatically affected by climate change (Downes, Storch, Moon, & Rujner, 2010). In Vietnam, climate change has led to an ongoing rise in the sea level and an increase in the occurrence of extreme weather events that affect the population living in low elevation coastal zones and riverbanks.

One benefit of economic growth is that the government and companies have greater resources to spend on improving infrastructure and storing more materials and supplies before disasters. On the other hand, rapid population growth and urbanization can cause deterioration in terms of both natural resources and the environment, as well as increase vulnerability to natural disasters (*Vietnam Disaster Management Reference Handbook*, 2018). In particular, its high population density has increased the population concentration along coastal areas and natural-disaster-prone areas. Urbanization and industrialization bring with them high-density buildings and industrial zones, and thereby increase the risk of man-made hazards such as fires and transport accidents. Furthermore, an economy at an intermediate stage of development is typically more integrated both between sectors and between regions, increasing spillovers and multiplying the adverse effects resulting from disasters (Benson & Clay, 2004). As an example, a disaster that affects the agricultural sector would spread more broadly in the economy through inter-sectoral linkages. Hence, higher vulnerability to hazards and incidents require more stringent efforts on the part of the government to improve the country's emergency management system.

2.3.2. Legal documents of emergency management

2.3.2.1. List of key legal documents

The management of natural and man-made disasters is regulated by several laws that are shown in Table 2-1 for the period of 2000 to 2017. As an example of coding in Vietnamese Law, the legal code No. 33/2013/QH13 denotes 33 as the number of the law that was passed in the year 2013 by the National Assembly, QH13.

Table 2-1. Key legal documents on emergency management in Vietnam

Year	Laws/Ordinances	Secondary legislation (Decrees and Decisions)
2000	**- Ordinance on Floods and Storm Prevention and Control** No. 27/2000/PL-UBTVQH10 (amended the Ordinance No. 09-L/CTN in 1993). **- Ordinance on the State of Emergency** March 23, 2000	Decision No. 127/2000/QD-BNN-KL promulgating the regulation on grades of forest fire forecast and alarm, and measures to organize forest fire prevention and control.
2002		Decree No. 71/2002/ND-CP on detailing the implementation of a number of the Ordinances on the State of Emergency in case of a great disaster or dangerous epidemic.
2004	**Law on Forest Development and Protection** No. 29/2004/QH11	
2006	**Law on Dikes** No. 79/2006/QH11	- Decree No. 09/2006/ND-CP on forest fire prevention and control. - Decree No. 23/2006/ND-CP detailing the implementation of the Law on Forest Development and Protection.
2007		- Decision No. 78/2007/QD-TTg on promulgating the regulation on earthquake and tsunami prevention and control. - Decree No. 113/2007/ND-CP to stipulate in detail and guide the implementation of a number of articles of the Law on Dikes. - Decision No. 172/2007/QD-TTg to approve the National Strategy on natural disaster prevention, response, and mitigation to 2020.
2008		Decision No. 158/2008/QD-TTg to approve the national target program to respond to climate change.
2009		- Decision No. 76/2009/QD-TTg on strengthening the national committee on search and rescue; and search and rescue systems of Ministries and local authorities. - Decision No. 1002/2009/QD-TTg to approve a project on community awareness raising and community-based disaster risk management.
2011		Decision No. 2139/2011/QD-TTg to approve the national climate change strategy.
2012	**Law on Water Resources** No. 17/2012/QH13 (replaced the Law of 1998)	Decision No. 1474/2012/QD-TTg on the issuance of a national action plan on climate change, period 2012–2020.
2013	**- Law on Land** No. 45/2013/QH13 (replaced the Law of 2002)	- Decision No. 02/2013/QD-TTg to promulgate the regulation on oil spill response.

	- Law on Natural Disaster Prevention and Control No. 33/2013/QH13 **- Law on Fire Prevention and Fighting** No. 40/2013/QH13 (replaced the Law of 2001) **- Law on Terrorism Prevention and Control** No. 28/2013/QH13	- Decree No. 201/2013/ND-CP detailing the implementation of a number of articles of the Law on Water Resources.
2014	**Law on Environmental Protection** No. 55/2014/QH13 (replaced the Law of 2005)	- Decree No. 66/2014/ND-CP detailing the implementation of a number of articles of the Law on Natural Disaster Prevention and Control (replaced Decree No. 14/2010/ND-CP). - Decree No. 79/2014/ND-CP detailing the implementation of a number of articles of the Law on Fire Prevention and Fighting. - Decision No. 44/2014/QD-TTg on detailed regulations of natural disaster risk levels. - Decision 1041/2014/QD-TTg to approve the master plan on incident and disaster response and search and rescue activities through 2020.
2015	**Law on Natural Resources and Environment of Sea and Islands** No. 82/2015/QH13	Decree No. 19/2015/ND-CP on detailing the implementation of a number of articles of Law on Environmental Protection.
2017		Decree No. 30/2017/ND-CP on regulating the response to emergencies, natural disasters, and search and rescue.

The Ordinance on Flood and Storm Prevention and Control was passed by the Standing Committee of the National Assembly in 1993, revised in 2000 (*No. 27/2000/PL-UBTVQH10*, 2000), and was seen as the first legal document that directly addressed natural disasters by providing a framework for preventing and controlling floods and storms. The Ordinance defines the Ministry of Agriculture and Rural Development (MARD) as the focal Ministry in charge of flood and storm prevention and control, while the People’s Committees (PCs) at three local levels shall conduct the state management of activities for the prevention and control of floods, storms, and overcoming consequences in their territories. The People’s Committee includes a chairman and leaders of governmental organizations who are responsible for formulating and implementing policy at local levels. The chairman is a leader of a government structure in a specific province, district, or commune. A few types of natural disasters, such as heat waves, damaging cold, earthquakes, and tsunamis, were not addressed in the Ordinance.

The Law on Dikes (*Law on Dikes, No. 79/2006/QH11*, 2006) was approved in 2006 and provides outlines for anti-flood plans for diked rivers, dike planning, dike construction, and dike management and protection. This Law is connected to natural disaster prevention because dikes are traditional structures for controlling floods in Vietnam. The Law specifies that the chairmen of the PCs at all levels should mobilize forces and supplies for dike protection and salvage, as well as decide on strategies for evacuating communities from dangerous areas during disasters. In the event of their inability to adequately respond to such situations, chairpersons of local PCs have to request reinforcements from the upper levels of government. At the national level, the MARD is the primary agency for directing dike management and the Ministry of National Defense (MND) is in charge of mobilizing army forces to act as the main responders of dike salvage.

Law on Natural Disaster Prevention and Control (*No 33/2013/QH13*, 2013), passed by the National Assembly on June 19, 2013, provides regulations on natural disaster countermeasures, and details the rights and obligations of agencies, organizations, households, and individuals engaged in natural disaster prevention and control activities (*No 33/2013/QH13*, 2013). Currently, this Law is the most important and comprehensive legal document for natural disaster prevention and control, as it provides principles of natural disaster management and specifies key authorities in natural disasters. Its core principles are that natural disaster prevention and control activities are assigned and decentralized and must be integrated into national and local socio-economic development master plans. Natural disaster prevention and control follows the motto "four on-the-spot": command on the spot, manpower on the spot, means and supplies on the spot, and logistics on the spot (*No 33/2013/QH13*, 2013), Article 4). The Law puts explicit pressure on strengthening the role of preventive and long-term risk mitigation across all administrative levels in order to overcome the current fairly reactive disaster risk management.

While the Vietnamese legislation on natural disaster management has recently been updated to a rather comprehensive legal system, laws on man-made disaster management have been separated into various related legal documents and classified by types of incident. There are specific laws on man-made disasters such as Law on Fire

Prevention and Fighting (*Law on Fire Prevention and Fighting, No. 40/2013/QH13*, 2013) and Law on Terrorism Prevention and Control (*No. 28/2013/QH13*, 2013). Moreover, other laws have sections that mention disaster issues. In particular, Article 42 of Law on Forest Development and Protection (*No. 29/2004/QH11*, 2004) mentions the responsibilities of forest owners in forest fires and countermeasures, while Article 2 in Law on Natural Resources and the Environment of Sea and Islands (*No. 82/2015/QH13*, 2015) regulates principle oil spill response and recovery. Law on Water Resources (*No. 17/2012/QH13*, 2012) provides regulations for the prevention and control of water source pollution in Article 26, and responses to and remedies for water sources pollution incidents in Article 27. Law on Environmental Protection (*No. 55/2014/QH13*, 2014) provides principles for climate change response from Article 39 to 48.

The Decree on the State of Emergency (*No. 71/2002/ND-CP*, 2002) was passed by the Prime Minister for large disasters and dangerous diseases. In such a case, the President of Vietnam declares a State of Emergency and special application measures during events. A Steering Committee composed of various ministers and chairmen of local areas will be established at the discretion of the Prime Minister. A State of Emergency will be declared in the incidence of natural disasters with risks at level four and above. In Decision on detailed regulations on natural disaster risk levels *(No. 44/2014/QD-TTg*, 2014), disaster risk is classified into five ascending levels, ranging from one to five. This classification is based on predicting and recording the intensity, range of influence, exposed areas, and possible damage inflicted by the disaster. At higher disaster risk levels, larger co-operation and more resources are deployed, which is made possible by the activation of higher-level of coordinating committees.

Vietnam's government has recently enacted and updated a number of strategies including the Decision to approve the national strategy on natural disaster prevention, response and mitigation to 2020 (*No 172/2007/QD-TTg*, 2007). It provides guidance for conducting the strategy and mentions structural and non-structural measures that may be used for disaster prevention and mitigation. The principles used for disaster prevention, response, and mitigation in Vietnam are the "four on-the-spot" principle, proactive prevention, timely responses, and quick and effective recovery (*No*

172/2007/QD-TTg, 2007). This strategy emphasizes the government's increased attention to disaster mitigation that specifies proactive measures that are to be taken before an emergency or disaster occurs. As this is the first time it appears in a legal document, disaster mitigation is mentioned together with disaster preparedness and response throughout the contents of the National Strategy. In the context of global climate change, the National Target Program in Response to Climate Change was approved by Decision No. 158/2008/QD-TTg (2008). It mentions that climate change must be integrated into development strategies, legal documents, programs, and plans in all sectors and at all levels following the principle of sustainable development. Following this, the National Climate Change Action Plan was approved by Decision 1474/2012/QD-TTg (2012) to implement strategic tasks in the National climate change strategy, including enhancing awareness and the capacity to adapt to climate change and to develop a low carbon economy.

In Vietnam, the emergency management of natural and man-made hazards is regulated in different laws other than a general law. However, the Master Plan on incident and natural disaster response and search and rescue activities through 2020, passed by Decision 1041/QD-TTg (2014), can be seen as a legal document considering main stakeholders in responding to all types of hazards. The objectives of the Master Plan are to consolidate and strengthen organizations and agencies in incident and natural disaster response and search and rescue at all levels, and to perform effective direction and administrative work. After the Master Plan, Decree 30/2017/ND-CP (2017) on regulating the response to emergencies, natural disasters, and search and rescue provides the principles for emergency response and the responsibilities of relevant organizations. In particular, the Decree considers emergency events, including both natural and man-made disasters, for regulating response and search and rescue.

2.3.2.2. The development of key legal documents

The development of Vietnamese legislation to cover different types of natural disasters is reflected by comparing items in the Ordinance on Floods and Storm Prevention and Control in 2000 (*No. 27/2000/PL-UBTVQH10*, 2000) and the Law on Natural Disaster Prevention and Control (*No 33/2013/QH13*, 2013). In Vietnam, the flow of legislative development and policy formulation in emergency management is historically constructed from countermeasures focusing on natural disaster prevention and control. The Ordinance on Floods and Storm Prevention and Control focused on addressing specific types of natural disasters including typhoon and water-related disasters. Other types of natural disasters were not mentioned in this Ordinance such as seawater intrusion, extreme hot weather, droughts, earthquakes, and tsunamis. Therefore, the Law on Natural Disaster Prevention and Control issued in 2013 becomes the most integrated piece of legislation for natural disaster prevention and control. The Law covers all types of natural disasters including typhoons, flood, seawater intrusion, extreme hot weather, droughts, earthquakes, tsunamis, and other types of natural disasters. Natural disaster prevention and control refers to a systematic process involving the prevention of, response to, and remediation of the consequences of natural disasters. It also specifies the rights and duties of organizations in natural disaster prevention and control. Moreover, the names of the CSCNDPC at the national level and CNDPC&SRs at the local level that reflect the roles of these committees were revised in 2014. The names of these committees now include “natural disaster” instead of “flood and storm” as seen in previous names.

From 2013, significant efforts have been observed from Vietnam’s government by promulgating a number of laws related to man-made disasters. Law 40/2013/QH13 on Fire Prevention and Fighting and Law 28/2013/QH13 on Terrorism Prevention and Control (please refer to Table 2-1) were issued in 2013. Two years later, the Vietnamese National Assembly passed Law 82/2015/QH13 on Natural Resources and Environment of Sea and Islands that provides the principle of oil spill response and recovery.

The period of development of Vietnamese legal documents to cover different types of disasters took place in the same time frame as the implementation of the HFA from 2005 to 2015. In Vietnam’s national progress report on the implementation of the HFA (United Nations Development Programme - Vietnam, 2015), the multi hazard integrated approach is one of the drivers of progress that was partially achieved in Vietnam. Although this approach was acknowledged in national strategy and new laws, there were still difficulties in its implementation (United Nations Development Programme - Vietnam, 2015, p. 59). Our findings reveal that Decision No.

172/2007/QD-TTg, Law No 28/2013/QH13, Law No. 33/2013/QH13, Law No. 40/2013/QH13, Law No. 55/2014/QH13, and Decision 1041/2014/QD-TTg are the most important legal documents in exemplifying the shift in viewpoints to manage different types of disasters in Vietnam. All of these legal documents were passed after the promulgation of the HFA.

2.3.3. Governmental structure of emergency management

Vietnam's emergency management system includes several organizations among government agencies, socio-political organizations, and private sector institutions. Rather than establishing a national emergency department, as the United States did with the Department of Homeland Security and FEMA, many different departments of the Vietnamese government share the functional responsibility for disaster prevention, control, and search and rescue obligations. Vietnam has established national coordinating committees according to different types of disasters that involve members of government and leaders of related ministries and organizations. Established at all local government levels, specialized coordinating committees for emergency management are led by the chairpersons of the PCs.

First, the Central Steering Committee for Natural Disaster Prevention and Control (CSCNDPC) is responsible for coordinating natural disaster prevention, response, and recovery activities at the national level. The chairperson of the CSCNDPC is the Minister of the MARD, and members of the CSCNDPC are heads of ministerial-level agencies and related social-organizations. The CSCNDPC has the responsibility of guiding and urging the implementation of strategies, national plans, and policies on natural disaster prevention and control, and directing disaster response and mobilizing the resources of the ministries, ministerial-level agencies, government agencies, organizations, and individuals to respond to and recover from natural disasters. Second, the National Committee for Incident and Disaster Response and Search and Rescue (VINASARCOM) is the leading committee for search and rescue in disasters, with the MND acting as the standing agency responsible for its operations. VINASARCOM is responsible for supporting the Prime Minister in enhancing cooperation among the ministries and provinces in emergency response for search and rescue in disasters. The

Deputy Prime Minister is the chairperson of VINASARCOM, while the five vice-chairmen are the heads of the MND, the MARD, the Ministry of Public Security, the Ministry of Transport, and the Deputy Director of the Government's office. Ministerial Committees for Disaster Prevention and Control and search and rescue are established by the heads of the Ministries to implement tasks in accordance with the given responsibility areas of the Ministries. Figure 2-2 shows the governmental structure for disaster management and search and rescue in Vietnam. At local levels of government, committees for natural disaster prevention and control and search and rescue (CNDPC&SRs) are established in provinces/cities, districts, and communes, and are chaired by members of PCs who are directly responsible for conducting disaster response and search and rescue within their territories. Department of Agriculture and Rural Development (DARD) is the standing agency at provincial level.

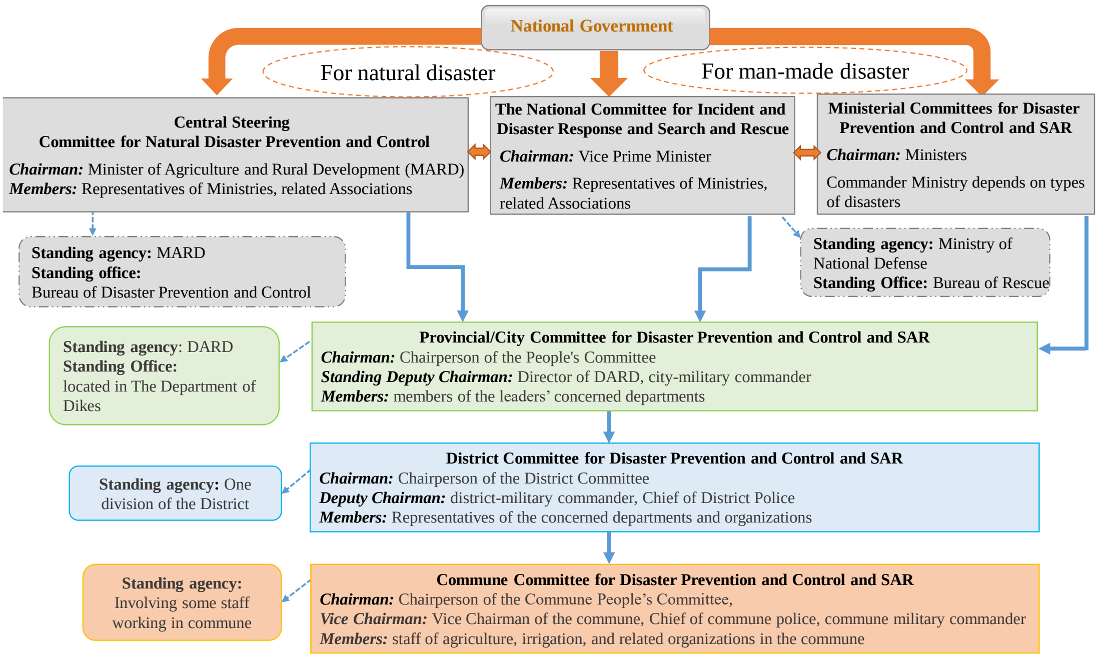


Figure 2-2. Governmental structure of Emergency management in Vietnam.

Table 2-2 explains the relationships among related response committees and agencies to different types of emergencies/incidents. I use the term incident to refer to major disasters and other types of emergency events from both natural and man-made sources. Coordinating committees, primary agencies, and support agencies are defined depending on the type and risk level of a given disaster. In this table, the concepts of coordinators, primary agencies, and support agencies are borrowed from FEMA

(Emergency Support Function Annexes, 2008). Coordinating committees are ad-hoc committees that gather leaders from related primary and support agencies to coordinate disaster management. Primary agencies at the national level are standing Ministries with significant resources and capabilities for responding to specific types of disasters. Support agencies are other related ministries and organizations with specific capabilities and resources for supporting primary agencies during incident response. According to the Master plan, VINASARCOM is responsible for coordinating the forces and means of ministries and national forces for search and rescue activities for all types of disasters. The CSCNDPC is issued responsibilities related to natural disasters, while local CNDPC&SRs coordinate committees within their territories for all types of incidents.

Table 2-2. Government agencies for incident response

	Types of incidents										
	#1 - Ship and boat accidents	#2 - Oil spill incidents	#3 – Oil, gas, fire, and explosions	#4 - Fire incidents in buildings, urban	#5 - Collapse of works, buildings	#6 - Incidents of radioactive or nuclear radiation leaks	#7 - Traffic accidents (includes flight accidents)	#8 - Terrorism	#9 - Earthquakes and tsunamis	#10 - Forest fire incidents	#11 - Storms, floods, and landslides, breakdown of dikes
National Committee for Incident and Disaster Response and Search and Rescue. (VINASARCOM)	C	C	C	C	C	C	C	C	C	C	C
Central Steering Committee for Natural Disaster Prevention and Control (CSCNDPC)											C
National Committee for Traffic Safety							C				
Central Steering Committee for Urgent Matters in Forest Protection and Forest Fire Prevention and Fighting										C	
National Committee for anti-terrorism								C			

	Types of incidents										
	#1 - Ship and boat accidents	#2 - Oil spill incidents	#3 – Oil, gas, fire, and explosions	#4 - Fire incidents in buildings, urban	#5 - Collapse of works, buildings	#6 - Incidents of radioactive or nuclear radiation leaks	#7 - Traffic accidents (includes flight accidents)	#8 - Terrorism	#9 - Earthquakes and tsunamis	#10 - Forest fire incidents	#11 - Storms, floods, and landslides, breakdown of dikes
Local Committees for Disaster Prevention and Response and Search and Rescue	C	C	C	C	C	C	C	C	C	C	C
Ministry of Agriculture and Rural Development										P	P
Ministry of National Defense	S	P/S	S	S	P/S	S	S	P	P	S	S
Ministry of Transport	P						P	P	S		S
Ministry of Industry and Trade		P/S	P		P/S	S					S
Ministry of Natural Resources and Environment		S				S			S		S
Ministry of Public Security			S	P	P/S	S	S		S	S	S
Ministry of Construction					P/S						
Ministry of Science and Technology						P			S		
Vietnam Academy of Science and Technology									S		
Ministry of Health							S				

Legend: C = Coordinating committees, P = Primary agencies, S = Support agencies

2.3.4. Exercise programs in Vietnam

By reviewing details on Vietnamese legal documents, types and frequency of exercise have been defined. Law on Natural Disaster Prevention and Control *(No 33/2013/QH13, 2013)* mentions that all of local governments need to conduct seminar, workshops, and drills for stakeholders according natural disaster management plans. The Decree on detailing the implementation of a number of articles of the Law on Fire Prevention and Fighting *(No. 79/2014/ND-CP)* requires facilities conducting drills at least once a year, while decision to promulgate the regulation on oil spill response *(No 02/2013/QD-TTg)* requires ports/facilities conducting drills one time in six months. The Law on Terrorism Prevention and Control *(No 28/2013/QH13)* also mentions necessary of practising plan through drills. Through these legal documents, drill is main type of emergency exercise for forces in Vietnam. There is lack of regulations on doing Table-top and functional exercise. By searching table top and functional exercise in Vietnam in the internet, I found that some organization conducted training programs to operate cooperation mechanism among several stakeholders. For examples: "Prevention of terrorism at the Thong Nhat Hospital" (HCM City in 2015); "Operation mechanism of search and rescue for airplane" by Vietnam Flight Management Corporation (HoaBinh, RachGia in 2017). There are also similar type of exercise to operate the armed forces mechanism in training Defense forces. However, details of these exercise were not published, as well as lacking of information on evaluation program of these exercises.

2.3.5. The institutional structure for responding to natural disasters following the functions of the ISO 22320

The international standard ISO 22320 was promulgated in 2011 to enhance the capabilities of organizations to handle all types of incidents in considering a multi-organizational approach to emergency response. The standard provides minimum requirements for implementing an effective emergency response that focuses on the following functions:

a. Command and control: specifies the roles and responsibilities of organizations and structures, levels of incident response, functions, decision-making processes, and resource management.

b. Operational information: functions as part of the command and control process to manage incident response activities including timely, accurate, complete, and relevant information.

c. Coordination and cooperation: requires organizations to access the need for coordination and cooperation among the involved parties and among different sections of organizations.

The following sections will provide discussions on the characteristics of related organizations in Vietnam's emergency response structure that is focused on the scope of natural disasters.

2.3.5.1. Command and control

At the national level, the CSCNDPC is in charge of natural disaster prevention and control while VINASARCOM is the coordinating committee responsible for responding to all types of incidents and disasters. The CSCNDPC is the lead committee responsible for implementing the National Strategy for Mitigation, Prevention, and Control of Natural Disasters through the MARD, which acts as a standing agency. On the other hand, the MND plays a role as the standing authority of VINASARCOM (*No. 30/2017/ND-CP*, 2017, Article 6). There are different standing authorities for these committees because of their different responsibilities on emergency management at the national level. While VINASARCOM is in charge of response, search, and rescue in not only natural disasters but also in other incidents, the CSCNDPC is more focused on natural disaster prevention and control. Furthermore, as prescribed in Article 20, Decree on detailing and guiding a number of articles of the Law on Natural Disaster Prevention and Control (*No 66/2014/ND-CP*, 2014), the provincial levels of CNDPC&SRs are established to advise and assist provincial-level PCs in managing, commanding, and administering natural disaster prevention and control as well as search and rescue activities in their localities. The provincial-level People's Committee chairperson is the CNDPC&SRs chairperson, while the members are leaders of provincial-level departments and local agencies. In the CNDPC&SR, the leader of DARD is the vice chairperson in charge of natural disaster prevention and control, while the leader of the provincial-level military command is the vice chairperson in charge of natural disaster relief and rescue.

ISO 22320 suggests that the command and control structure shall be divided into different levels where different types of decisions are made, for example, operational, tactical, strategic, and normative levels (*ISO 22320*, 2011). Table 2-3 explains the levels of commanders among related organizations in natural disaster response by adopting the classifications of ISO 22320

Table 2-3. Command and control structure for natural disaster response in Vietnam

Command level	Commander	Relevant Committees/Agencies
Normative	- Prime Minister (1) - Chairperson of the National Committee for Incident and Disaster Response and Search and Rescue - Chairperson of the Central Steering Committee for Disaster Prevention and Control	- National Government - National Committee for Incident and Disaster Response and Search and Rescue - Central Steering Committee for Disaster Prevention and Control
Strategic	- Minister of the Ministry of National Defense. - Minister of the Ministry of Agriculture and Rural Development - Chairperson of the Province/City's People's Committees - Chairperson of the District's People's Committees - Chairperson of the Commune's People's Committees	- MND - MARD - Province/City level CNDPC&SR - District-level CNDPC&SR - Commune-level CNDPC&SR
Tactical (2)	- Leaders of incident response agencies belong to Ministries - Directors of Departments belong to local governments	- Incident response centers located in the cities - Related departments and divisions at each level
Operational	- Leaders of incident response forces: militia, self-defense forces, police - Volunteer organizations, and so forth.	- Militia, self-defense forces, police -Volunteer organizations: Red cross society, youth organizations, and other local forces
Note: *(1): In case of a "Stage of Emergency," the Prime Minister establishes a Steering Committee as Decision 71/2002/ND-CP.* *(2): Related agencies in this command level are specified in the Local Natural Disaster Plan.*		

The level of resources deployed in incident response is determined by the disaster risk level. Table 2-4 summarizes the range of natural disaster risk levels in each type of hazard in Vietnam and the relevant coordinating committee responsible for responding to it.

Table 2-4. Levels of natural disaster risk and relevant coordinating committees

Type of hazard	Risk level 1	Risk level 2	Risk level 3	Risk level 4	Risk level 5
Tropical depression and storm			◆—	—	→
Tornado, thunderbolt, and hail	◆—	→			
Heavy rain	◆—	—	→		
Extreme heat	◆—	—	→		
Drought	◆—	—	—	→	
Cold, Frost	◆—	—	→		
Fog	◆—	—	→		
Flood	◆—	—	—	—	→
Flash flood	◆—	—	→		
Landslide and ground subsidence	◆—	→			
Salinity intrusion	◆—	→			
Rising water levels	◆—	—	—	—	→
Strong wind at sea	◆—	—	→		
Earthquake	◆—	—	—	—	→
Tsunami			◆—		—→
Highest levels of Coordinating Committees	District CNDPC&SRs	Provincial CNDPC&SRs	CSCNDPC VINASARCOM	CSCNDPC VINASARCOM	National Committee for the Stage of Emergency

In considering the requirements in the command and control system as specified in ISO 22320, the response system is scalable for different scales of natural disasters and involves different organizations and agencies by establishing coordinating committees at all levels. In Vietnam, the command and control system for natural disaster management is a graded response and functional division, applying the motto "four on-the-spot." Graded response means that the different levels of leaders or commanders change according to the disaster's risk levels. Functional division means that the relevant sectors become primary agencies for incident response with their respective responsibilities, while the "four on-the-spot" principle emphasizes the responsibilities of grassroots-level disaster response. The chairperson of the local PC is assigned to the leadership role to mobilize forces for disaster response in their territories.

In principle, military force plays an essential role in emergency response and search and rescue (Article 4, *Decree on regulating the response to emergencies, natural disasters, and search and rescue, No. 30/2017/ND-CP*, 2017). At the national level, the MND acts as a standing agency in VINASARCOM, while local military and police commanders are members of provincial-level CNDPC&SRs. In natural disasters at risk levels one and two (without the coordination of VINASARCOM), the chairmen of PCs are assigned the role of the final decision makers during disaster response in their territories, while the local military commander acts as the vice chairperson of CNDPC&SR under the direction of the chairperson. Local military commanders and police commanders are still under national control from higher commanders in the armed and police forces. This shows both the horizontal and vertical command and control routes of local military and police forces in emergency response. Local military commanders receive directions and report to more than one supervisor, and therefore the decision-making network is not under the regime of "unity of command." The concept of "unity of command" means that there is only one leader and one report route for the management structure in an organization (Marume & Jubenkanda, 2016), as is the case with NIMS of the United States. In Vietnam, the coordination mechanism and report network during emergency response among local military and police with leaders of local PCs and Ministries should be classified to avoid overlap directions during emergency response and to reduce time reporting tasks.

2.3.5.2. Operational information

Decree 66/2014/ND-CP (2014) outlines the responsibilities for information transmission and the frequency of operation for communication networks for delivering the direction and command of responding to natural disasters. At the national level, Vietnam Television and Radio are responsible for broadcasting directions on natural disaster response from the Prime Minister, CSCNDPC, and VINASARCOM to the public. The standing offices of the committees are then in charge of delivering the direction and instructions from national committees to local committees, socio-economic organizations, and others. After receiving specific information from the national level, the standing office of CNDPC&SRs will transfer and then update the status of disasters and directions to the related departments, sectors, and socio-economic organizations and the lower levels of standing offices. As members in the provincial level CNDPC&SRs, leaders of the Department of Information and Communication and City Television are in charge of ensuring effective public communication.

Communication networks and equipment for the direction and command of natural disaster response are shown in Table 2-5. In the mass media network, Vietnam Television and local radios broadcast updated information on natural disasters every hour for risk levels four and five, and at least once every three hours for those at level three.

Table 2-5: Communication networks for direction and command during natural disasters

Public communication networks	Special-use information networks	Information devices
- Ground fixed telecommunication networks, satellites	- Hotlines directly serving the direction and command	- Telephone/Fax
- Ground mobile telecommunication networks, satellites	- Specialized telecommunication networks serving agencies	- Radio/Television devices
- Radio and television transmission and broadcasting networks	- Postal networks serving specialized agencies	- Computers
- Public postal network	- Information networks for tsunami warnings	- Automatic observation and information transmission

As in ISO 22320, operational information processes should include missions on planning and direction, collection, processing and exploitation, analysis and production, dissemination and integration, and evaluation and feedback (*ISO 22320*, 2011). At the national level, both the CSCNDPC, through the MARD, and VINASARCOM, through the MND, are respectively in charge of natural disaster management and emergency response. In lower-level structures, each local government establishes a CNDPC&SR as an inter-sectorial coordinator. In the provincial CNDPC&SR, the DARD is the standing body while one specialized division of the DARD acts as the standing office for the CNDPC&SR. Although military and police forces play core roles in incident response and search and rescue, representatives of military and police forces are not members of the standing offices of CNDPC&SRs.

Since recent legislation (Article 8, *Decree on regulating the response to emergencies, natural disasters, and search and rescue, No. 30/2017/ND-CP*, 2017) provides larger duties for CNDPC&SRs in various types of incidents, enhancing the capabilities of the standing offices of CNDPC&SRs in operational information processes is extremely important. In addition to the communication networks and equipment that are regulated in Decree 66/2014/ND-CP (2014), human capacity is also an essential factor in meeting the needs of disaster response, especially within the part-time basis system and rotation of personnel.

2.3.5.3. Cooperation and coordination

In natural disaster response, cooperation and coordination activities are conducted mainly by VINASARCOM and CSCNDPC at the national level and by CNDPC&SRs at local levels. The main tasks of the coordinating committees at all levels and their responsibilities are shown in Table 2-6.

In natural disaster response, the chairperson of the CNDPC&SR provides directions and requests to each committee's members to ask them to mobilize their forces. The committees' members are leaders of different organizations who have the authority to mobilize their forces. Local disaster-management plans provide general roles for each party during a natural disaster.

Table 2-6: Tasks of coordinating committees in natural disasters

Coordinating Committee	Main Tasks
The National Committee for Incident and Disaster Response and Search and Rescue	- To assist the Prime Minister to direct, organize, and coordinate search and rescue activities in the country and international cooperation. -To establish and train professional and unprofessional forces for search and rescue activities in the country. - To direct, mobilize, and coordinate the forces and means of the Ministries, Sectors, and localities to participate in search and rescue activities in large-scale disasters.
The Central Steering Committee for Natural Disaster Prevention and Control	- To guide the formulation of national strategies, policing, and plans on natural disaster prevention and control. - To direct and coordinate the response and recovery from disasters at disaster levels three and four; to support and co-ordinate localities at disaster levels one and two.

	- To decide on urgent measures and to mobilize resources at all levels.
Ministerial Steering Committees for Disaster Prevention and Control and Search and Rescue	- To decide on urgent measures and to mobilize the ministry's resources for responding to and recovering from disasters, to conduct search and rescue under Ministry management sectors, and to provide support to localities. - To coordinate with other Ministries and localities in disaster response under the direction of the Prime Ministry and the Central Steering Committee for Disaster Prevention and Control.
Provincial-level Committee for Disaster Prevention and Control and Search and Rescue	- To formulate and approve plans and projects to respond to natural disasters at the city level. - To command disaster response and search and rescue in their territory.
District-level Committee for Disaster Prevention and Control and Search and Rescue	- To formulate and approve plans and projects to respond to natural disasters at the district level. - To command disaster response and search and rescue in their territories.
Commune-level Committee for Disaster Prevention and Control and Search and Rescue	- To formulate and approve plans and projects to respond to natural disasters at the commune level. - To command disaster response and search and rescue in their territories. - To deliver authorities' direction to the community.

In coordination and cooperation, there is a challenge in uncontrolled mobilization and the over-response to disasters (McNally & Der Heide, 1992). Furthermore, it is difficult to accurately forecast natural disaster risk levels because of unprecedented extreme weather and climate events in the context of climate change. Although the highest level of coordinating committees is activated according to disaster risk levels (Table 2-4), emergency response principles in Vietnam rely on the "Four on-the-spot" motto. In this motto, the prepared items should meet the emergency relief demands of the household or its locality and ensure that they are ready to respond in times of disaster as well as provide support to other households before asking for support from other forces (*Four on the spot motto in disaster management*, 2010). Moreover, the active involvement of communities in all phases of disaster risk management is also emphasized in the framework on community-based disaster risk management in Vietnam (*Framework on Community-Based Disaster Risk Management in Vietnam*, 2011). I recommend that better coordination mechanisms between professional and local forces are necessary to ensure timely support at the local level for natural disasters and incidents of unexpected scale.

2.3.6. The motto "four on-the-spot" in Vietnamese emergency management

The motto "four-on-the-spot" was developed from lessons from practical experiences in protecting and strengthening the dike system in the early 1970s (*Four on the spot motto in disaster management*, 2010). The work required the local leader to be able to organize, coordinate, and mobilize all necessary resources from communities. Moreover, local participants were required to be proactive in taking on specific roles during the protection of the dike system. This idea was gradually developed into the motto "four-on-the-spot" in disaster management which included four components: leadership, human resources, means and materials, and logistics. The ideology underpinning the motto is based on enhancing the capacity of local communities and governments to solve local problems. The key point is to mobilize the power and resources of local forces in times of disaster with the spirit of "self protection and self rescue." (*Four on the spot motto in disaster management*, 2010)

Reflecting through policy, the motto is included in legal documents issued by the Vietnamese government. In 2007, the Vietnamese government approved the National Strategy on Natural Disaster Prevention and Mitigation to 2020 that states clearly in the third guiding principle: "natural disaster prevention and mitigation should be implemented using the motto four on-the-spot in order to assist people to actively prevent, respond in a timely manner to, and promptly." (*No 172/2007/QD-TTg*, 2007, p. 2). In 2013, the motto was mentioned as one of basic principles of natural disaster prevention and control in Section 3, Article 4 of the Law on Natural Disaster Prevention and Control (*No 33/2013/QH13*, 2013, p. 2). However, the definition or concept of the motto "four on-the-spot" was not provided in either of these legal documents. In the booklet produced by the Joint Advocacy Network Initiative (*Four on the spot motto in disaster management*, 2010), the concept of the motto generally means that each household or a certain area should prepare all essential items to prevent or respond to a natural disaster, which may occur at any given time.

As a typical example of natural disaster response, we reviewed Report No. 104/BC-PCTT of CSCNDPC to the Prime Minister after Tropical Storm Kujira affected Vietnam in June 2015. The storm was categorized as a Level 3 natural disaster risk. Responding from the national level, CSCNDPC and VINASARCOM sent an announcement to provincial CNDPC&SRs and related Ministries to provide official information about the typhoon and to ask for emergency response activities to the storm at local levels. In CSCNDPC, the Minister of MARD conducted a meeting with standing members and contacted the chairpersons of related provincial CNDPC&SRs, while the MND directed the Vietnam People's Coast Guard to cooperate with local governments to ensure the safety of ships in shelters and overall ship safety. At the local level, provincial CNDPC&SRs commanded the response to the typhoon and search and rescue in their locality following the motto "four on-the-spot." Leadership on the spot means that the chairman of the local People's Committee who is also the leader of the CNDPC&SR becomes the most senior leader in the command system. Human resources on the spot means that people should save themselves and rely on their own resources. This idea is learnt from a Vietnamese proverb: "distant water cannot put out a fire close by." In practice, local militia, self-defense forces, and the police on site are the main on-the-spot forces. Means and materials on the spot is that local communities need to ensure that they have adequate materials and supplies by carrying out actions co-funded by the government and people. Logistics on the spot requires that the local authority prepare adequate stocks of food and medicine to help people before external relief arrives. There is a common point between the concept of the motto and an approach of community-based disaster management because building the capacity of communities is emphasized.

2.4. Summary of Chapter 2

2.4.1. Conclusion

The main legal documents and organizational structure for emergency management in Vietnam have been reviewed in the chapter. By emphasizing the importance of the "multi-hazard approach" of emergency management, we found that Vietnamese legislation has gradually expanded to cover different type of disasters, especially from 2013 onwards. The Law on Natural Disaster Prevention and Control issued in 2013 covers different types of natural disasters. In the same year, other laws on managing man-made disasters were passed by the National Assembly, followed by a number of secondary legislations. Laws in Vietnam for emergency management mainly mention requirements to do drills as common type of training. By reviewing numbers of legal documents, the Vietnamese emergency response structure to natural disasters is described according to the three functions of the ISO 22320, including command and control, operational information, and cooperation and coordination. This chapter contributes to a better understanding of Vietnamese emergency management. I also encourage the study and survey of the emergency management of other nations to different types of disasters.

2.4.2. Further issues

There are long history of development legal and structures of Vietnamese organization to respond natural disasters. Meanwhile, recent development on legal documents are observed for man-made disaster such as oil spill, firefighting,… It needs more detailed studies on emergency management system for man-made disaster in Vietnam.

There is high demand for the enhancement of the capacities of CNDPC&SRs and local responders to perform their tasks. Key members in CNDPC&SRs who are leaders of local organizations might change their work positions after their job terms end or due to the rotation of personnel in the government. As principle of Vietnamese emergency management for both natural and man-made disaster, the motto “four on-the-spot” is emphasized that relies on the capabilities of local stakeholders. Therefore, communication among stakeholders becomes very important to effectively respond to disasters. However, common type of emergency exercise is drill for these organizations, that focus on operation of field responders. Exercise programs to enhance communication become necessary for emergency responders, for example table-top and functional exercise.

3. DEVELOPING AN APPROACH TO CHOOSE TOPICS OF EMERGENCY EXERCISES

3.1. Introduction

Emergency exercise helps organizations better preparation before emergency or disaster. Exercise is an instrument to train for, assess, practice, and improve performance in prevention, protection, response, and recovery capabilities (FEMA, 2012). Exercise program should be developed by considering practical conditions of organizations, communities. Among several steps to design exercise, the first step is doing need assessment with hazard identification (*IS-139.A: Exercise Design and Development*, n.d.). Hazard identification is one important task in emergency management in order to effectively assess vulnerabilities, threats and the potential risks (Cameron et al., 2017). Hazard identification is considered as an essential and fundamental step to successfully designing emergency exercises.

There is a lack of publication about the detailed approaches to choosing appropriate emergency exercise topics. Chapter 3 in Exercise Design and Development from Homeland Security Exercise and Evaluation Program (HSEEP, 2013) mentions that the exercise topic and scope should be selected by the exercise planning team. This team is established by gathering leaders or experts to determine the base of the exercise. For exercise to enhance communications such as table-top and functional exercises, members of the exercise planning team should come from different subject field areas. Therefore, it is necessary to combine opinions of team members to choose key elements that would be topics for emergency exercises.

AHP is a method, or technique, originally developed by Thomas L. Saaty in the 1970s, that employs paired comparisons and relies on the judgments of practitioners to derive priority scales for factors of an issue or system (Saaty, 2008). It is a quantifying tool and a multi-criteria technique that provides an effective and precise means of choosing options evident (Saaty, 1990, 2008; Soma, 2003). This method helps with the problem of multicriteria decision making for the situation in which there exists a prioritization of factors (Yadollahi & Rosli, 2011). AHP has been applied in many disciplines involving planning, resource allocation, priority setting and selection among alternatives (Bhushan & Rai, 2004). In emergency management, the use of AHP has been found in some research on flood disaster management (Nivolianitou, Synodinou, & Manca, 2015), and rehabilitation project ranking before a disaster (Yadollahi & Rosli, 2011). However, lack of research to apply AHP method for choosing topics for emergency exercise.

With a lengthy coastline of 3260 km, ports and shipping activities contribute on development of Vietnam's maritime economy and society. Vietnam is very close to the international seaway of the South China Sea, which has the highest density of vessel traffic in the world, while Haiphong city can be seen as a gateway to the seas in North of Vietnam. There are 38 port owners in Haiphong city in 2015. The development of numbers and cargo throughput in Haiphong ports are encouraged by Vietnam governmental policy on transportation system, particularly ocean shipping. In 2007, the Party Central Committee issued Resolution No. 09-NQ/ TW on the "Vietnam Maritime Strategy to 2020" which determined that the marine economy contributes 53–55 % of the gross domestic product. Because of the high importance and complexity of ports, adequate measures are needed to enhance safety and security at port areas. The greater the number of port and ship-calls in Haiphong city, the more concern over hazards related to port and shipping activities that require better preparation for emergency plan and exercises.

There is still lack of specific research for choosing topics of emergency exercise at port areas in Haiphong. Although port companies in Haiphong city conduct drills every year, they have not implemented table-top and functional exercise yet. Topics for table-top and functional exercise have not been developed for Haiphong ports. In some other countries, researchers concern about environmental hazards from both operation of ports and shipping activities including Darbra, Ronza, Stojanovic, Wooldridge, & Casal (2005), Peris-Mora, Orejas, Subirats, Ibáñez, & Alvarez (2005), Braathen (2011) and Klopott (2013). Moreover, there are interrelated among different types of hazards at port areas. For example, storage of hazardous waste provides threats in case of accidents such as fire and leakage (Saengsupavanich, Coowanitwong, Gallardo, & Lertsuchatavanich, 2009). Hence, specific research for raising potential exercise topics in emergency exercises at Haiphong ports can fill this gap.

The main objective of this chapter is to apply AHP method to find potential topics for implementing table-top or functional exercise in port areas in Haiphong city. Two concerns of emergency issues in this chapter are environmental and fire-related emergency because there are highly interrelated between two issues at port areas. In method section, we propose procedure of the research. Next sections are results and discussions for potential exercise topics for environmental and fire-related emergency at Haiphong ports.

3.2. Methodology

The Analytic Hierarchy Process (AHP) is a popular method for considering the decision making process based on multiple attributes (Yadollahi & Rosli, 2011). The general steps (Rangone, 1996; Zahedi, 1986) in manufacturing and solving decision problem include develop a hierarchical structure, collect data from questionnaire survey, calculate normalize weight of factors in the hierarchical structures, and combining and interpreting results. Since hazard identification is one important task to effectively assess vulnerabilities, threats and the potential risks (Cameron et al., 2017), we proposed five steps for choosing appropriate topics of emergency exercises at Haiphong ports.

3.2.1. Hazard identification

Hazard identification is identified by field survey, literatures and historical reviews on environmental hazards at port areas in Haiphong city. Hazard identification is necessary for an effective application of the AHP in emergency issues at Haiphong ports. Since solid waste from shipping activities becomes growing problems but lack of data for this issue at port areas in Haiphong city, a survey on characteristics of ship-waste was conducted to understand about hazards related to solid waste. The survey was initial design for identifying quantity and composition of garbage collected from ships. For purpose of design emergency exercise for Haiphong ports, data from the survey has been re-analysed for hazards identification, and used for providing information to interviewees during questionnaire survey. To identify other environmental hazards, we review environmental conditions from existing publications and historical records of incidents at port areas in Haiphong city.

3.2.2. Developing hierarchical structure

A hierarchical structure is a graphical representation that generally provides better understanding of the issues. They are validated by ensuring the structure is logical and complete (Saaty & Shih, 2009). The hierarchy in this study was achieved by breaking down the environmental and fire issues, with respect to emergency management, at Haiphong port areas into four levels. Level 1: Goal, Level 2: Factors, Level 3: Sub-factor 1 and Level 4: Sub-factor 2. Elements that have the same properties are grouped together and related according to their influence on the next levels.

In this study, the hierarchical structures are developed after understanding hazards at Haiphong ports from step 1, and further reviewing papers related to risks at ports areas. Level 1: Goal that was defined at port areas according to the target of research within the two emergency areas. Level 2 is relevant with the three components of risk: Hazard, Vulnerability and Capacity. Level 3 and 4 were created after reviewing researches and data on environmental issues at port, and firefighting drill plans at port. Information related to volume and composition of garbage from ships at Haiphong ports was found by field survey that provide more evidences to create the hierarchical structures.

3.2.3. Questionnaire survey

A questionnaire includes pair wise comparisons of all individual factors and sub-factors, then collects judgments of interviewees according to Saaty Comparison Scale (Table 3.1). The Saaty Comparison Scale is used for questionnaires to express the importance of one element over another. Interviewees will be asked to fill in answer questionnaires. To help interviewees have more information to select their answers, port facilities and results on solid waste survey were provided to them.

Table 3-1: Saaty Comparison Scale

Explanation	**Numeric Values**
If Option A and Option B are **equally important**: Mark X ➡	1
If Option A is **moderately more important** than Option B: Mark X ➡	3
If Option A is **strongly more important** than Option B : Mark X ➡	5
If Option A is **very strongly more important** than Option B : Mark X ➡	7

If Option A is **extremely more important** than Option B : Mark X ➡	9
Use even numbers for intermediate judgements ➡	2, 4, 6, 8

3.2.4. AHP data analysis

Data from individual questionnaires were analysed using AHP technique by inputting Super Decision software to calculate normalize weight of the individual factors and sub-factors. The normal process of AHP to calculate normalize weight is as follows:

- Consider n elements to be compared, $C_1 \ldots C_n$ and denote the relative "weight" (or priority) of C_i with respect to C_j by a_{ij} and form a square matrix $A=(a_{ij})$ of order n with the constraints that $a_{ij} = 1/a_{ji}$, for $i \neq j$, and $a_{ii} = 1$, all i. This is a reciprocal matrix

- Calculate the sum of each column of the reciprocal matrix. After we divide each element of the matrix with the sum of its column, we have relative weight. The sum of each column is 1. The normalized principal Eigen vector can be obtained by averaging across the rows. The normalized principal Eigen vector is also called priority vector. This vector shows normalized weight among elements that we compare.

- Check the consistency of the answer through the Consistency Ratio (CR). If CR is less than 10%, then the matrix can be considered as having an acceptable consistency. CR is the ratio of consistency index (CI) and the random index (RI). The Consistency Index (CI) can be calculated from $CI = (\lambda_{max} - n)/(n - 1)$. Where λ_{max} (Principal Eigen) value is obtained from the summation of products between each element of Eigen vector and the sum of columns of the reciprocal matrix. RI is Random Consistency Index. If n = 2, RI = 0; n = 3, RI = 0.58; n = 4, RI = 0.9; n = 5, RI = 1.12.

A Tutorial of the AHP calculation is further explained in the paper of Kardi Teknomo (2006).

3.2.5. Combining and interpreting results

As the results of normalize weight of the factors and sub-factors are different depending on opinions of interviewees, it is necessary to apply a method to combine the results after calculating normalized weight. Weighted arithmetic mean (WAMM) on priorities was selected to combine normalized weight that help to avoid an early aggregation. It is note that if CR of answers from interviewees for specific elements more than 10%, results from these answers are removed when combining normalized weight. Elements with high value of combined weight are highlighted on the hierarchical structure to show priority elements, that should be necessary for emergency exercise.

The summary of procedures and approach in this chapter is shown in Figure 3-1.

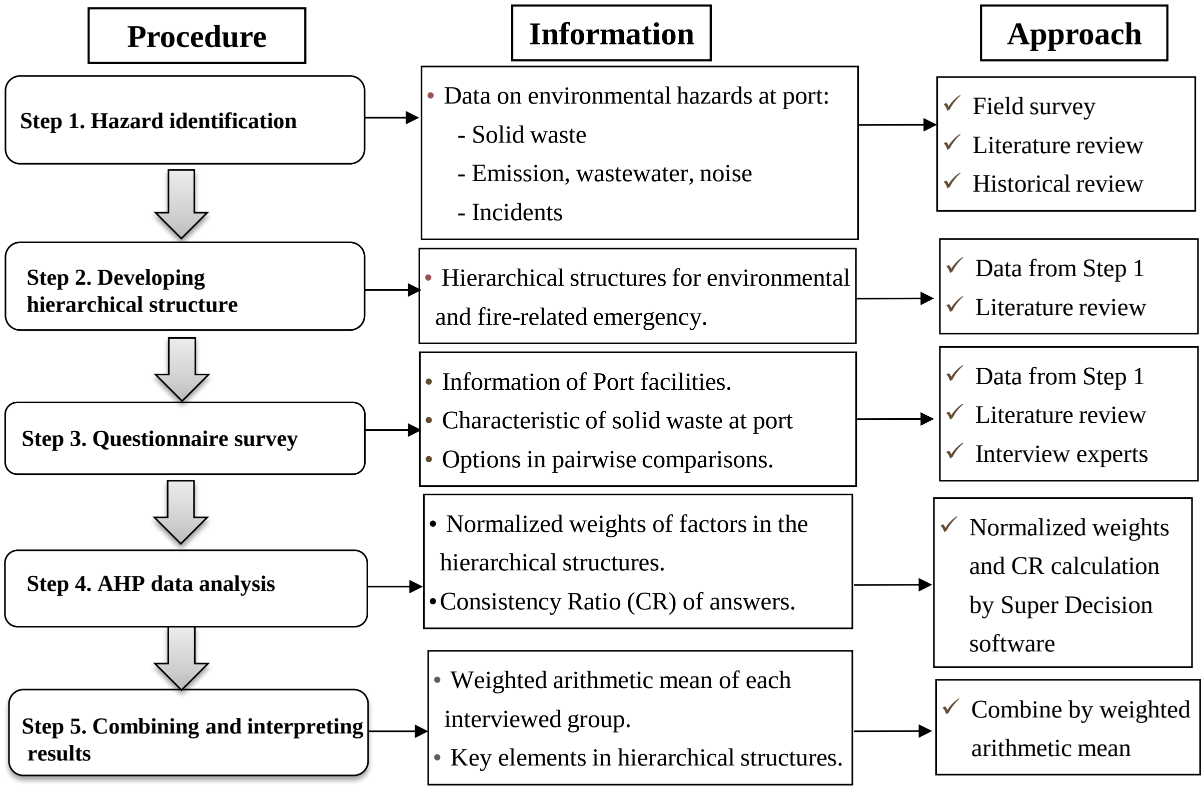


Figure 3-1. Procedure and approach to choose exercise topics

3.3. Results

3.3.1. Environmental hazards at Haiphong ports

3.3.1.1. Field survey on solid waste

a, Port selections

Among the 38 port owners, Haiphong port company is the biggest company in Haiphong city – this is a state-owner company. It was founded in 1876, and has the biggest cargo throughput among the ports in the North of Vietnam. Haiphong port consists of three belonged ports: HoangDieu, Chuave and Tanvu. Figure 3-2 shows location and characteristics of three ports in Haiphong city.

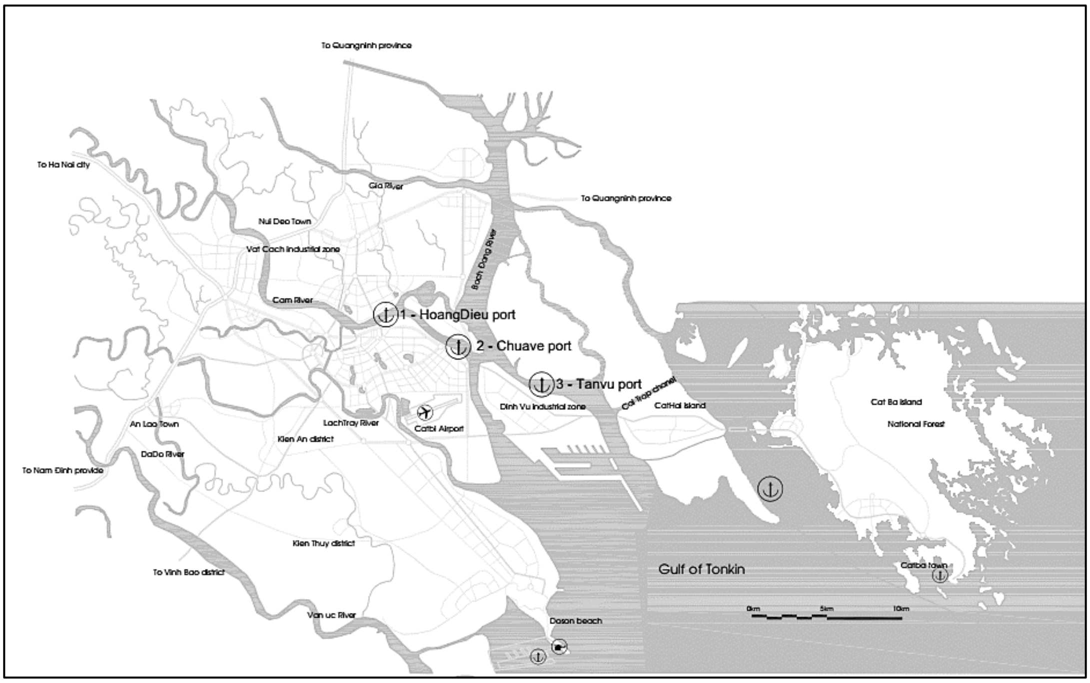


Figure 3-2. Location of three port areas

Located near the city center, HoangDieu port is the oldest port in the city that serves for both bulk ship and container ship. Chuave and Tanvu are newer port areas for receiving container ships with a higher depth of water compared to HoangDieu. Bulk ships are specially designed to transport unpackaged bulk cargo such as grains, and coal in their cargo holds while container ships carry seagoing non-bulk cargo. By packaging cargo into containers, container ships can transfer different kinds of cargo at the same time. There are 12 berths in HoangDieu port. Berths 1 to 3 are used for container ships and Berths 4 to 12 are for bulk ships. Chuave and Tanvu ports had been constructed to mainly accept container ships. Currently, there is clear transition on port function in these port areas. While HoangDieu is mainly used for the cargo handling of bulk ships, Chuave and Tanvu are the docking ports for container ships. Table 3-2 show overview of three port areas in Haiphong.

Table 3-2: Overview of three port areas in Haiphong

Port areas	Number of berths	Main type of docking ship	Equipment
HoangDieu	12	Bulk ship	Shore cranes, Forklifts, Automatic bagging line, Electronic scale
Chuave	10	Container ship	Shore cranes, Grantry crane, Elect scale
Tanvu	10	Container ship	Jib/slewing crane, gantry crane

Source: Website of Haiphong port (http://haiphongport.com.vn)

These port areas in Haiphong city were selected for the field survey on solid waste. Depending on each port area, ship-garbage collectors are directly or indirectly controlled by a joint company comprised of Haiphong Urban Environment Company (URENCO) and Haiphong Port Trading and Services. During the survey, we collaborated with the garbage collecting company to facilitate the survey process. The three port areas were favorable for conducting the survey accurately because the garbage collecting company is currently in charge of ship-garbage collection by three group workers. Compared with other smaller port areas in Haiphong, we could arrange better facilities and employees for the survey at these three port areas. In particular, we were able to provide sufficient number of vehicles to transfer garbage to gathering points and enough space for garbage separation near the three port areas. Therefore, the survey was targeted to collect data on the received garbage volume and the composition discharged from ships at three port areas.

b, Survey process

Before implementing the survey, we had discussions with various stakeholders in ship-garbage management at Haiphong ports, including ship operators, the garbage collecting company, the border guard at ports, and the Maritime Administration of Haiphong. Meeting with the garbage collecting company and Maritime Administration of Haiphong was necessary to obtain their permission to move forward with the field survey. From these meetings, these organization also confirmed that there is lack of data on characteristics of garbage collected from ships at these port areas. Due to time and budget constraints, we set a target of achieving at least 100 samples of garbage from ships.

In practical implementation, the survey was conducted in collaboration with the garbage collecting company and the shipping agency company. The first party was the implementing party and the second party was the monitoring party, which each had specific responsibilities. Daily from 8:00 to 11:30 a.m. during the survey period, garbage collectors visited all the ships that docked at the port to ask if they would use the garbage collection services. Because the use of port reception facilities is not a mandatory service at Haiphong ports, we were unable to collect samples and garbage from all docking ships during the survey period. In fact, 103 of 269 ship-calls had requested to discharge garbage from their ships. Survey dates varied slightly between

HoangDieu port and the two other ports. The survey start date at all areas was 20 Jan 2015; however, the end date at HoangDieu port was 7 Feb 2015 and at Chuave and Tanvu port areas was 6 Feb 2015. The end date differed in order to meet the minimum number of samples from ships. Table 3-3 provides the basic information of ships participating in the garbage composition survey. During the survey period, no container ship docked at HoangDieu port.

Table 3-3: Mean values (and standard deviations) of ships

Port areas	Number of samples	Type of docking ship	Crewmember (S.D.)	Deadweight in tons (S.D.)
HoangDieu	40	Bulk ship	16.3 (3.5)	7,272 (3,509)
Chuave	39	Container ship	18.6 (2.7)	9,917 (2,897)
Tanvu	24	Container ship	18.7 (3.2)	17,970 (5,105)

After collecting garbage on board, each type of garbage from each ship was stored and fully separated before weighing. The following garbage categories were classified by referring to the Annex V of MARPOL Convention Guideline. We then categorised ship-garbage into seven types based on recycling ability of each garbage fraction: Food waste, Glass, Paper, Plastics, Metal, Rags, and others. During collecting, transferring, separating, and weighing of ship-garbage, the monitoring party was in charge of checking all processes to ensure the accuracy of survey results. Each type of garbage on individual ship was separated and stored in plastic bags. Garbage separation was done both on board and at collecting points before transferring to the weight measurement process. In order to facilitate the garbage separation process as much as possible, each type of garbage was stored separately in nylon bags when collected on board.

c, Ship-garbage quantity and composition

Results of garbage quantity and composition collected from 103 ships at three port areas are shown in Table 3-4 and Figure 3-3.

Table 3-4: Garbage quantity

Port areas	Number of ships	Survey days	Received volume (kg)	Received garbage volume/day (kg/day)	Garbage volume/ship (kg/ship)
Hoangdieu	40	19	767.7	40.4	19.19
Chuave	39	18	861.9	47.9	22.10
Tanvu	24	18	1158.1	64.3	48.25

The largest amount of received ship-garbage was at Tanvu port: almost 1160 kg during 18 days. The weight of received garbage per ship among the three ports differed significantly. The mean quantity of received garbage per ship at Tanvu port was almost double that of the average values at HoangDieu and Chuave ports. This difference could be due to the following: first, the function of each port is different, while HoangDieu is used mainly for loading and unloading cargo from bulk ships; Chuave and Tanvu are used for container ships. Furthermore, the size of ships, as indicated by deadweight (DWT) in tons, docking in Tanvu port was almost double the size of ships in HoangDieu and Chuave ports.

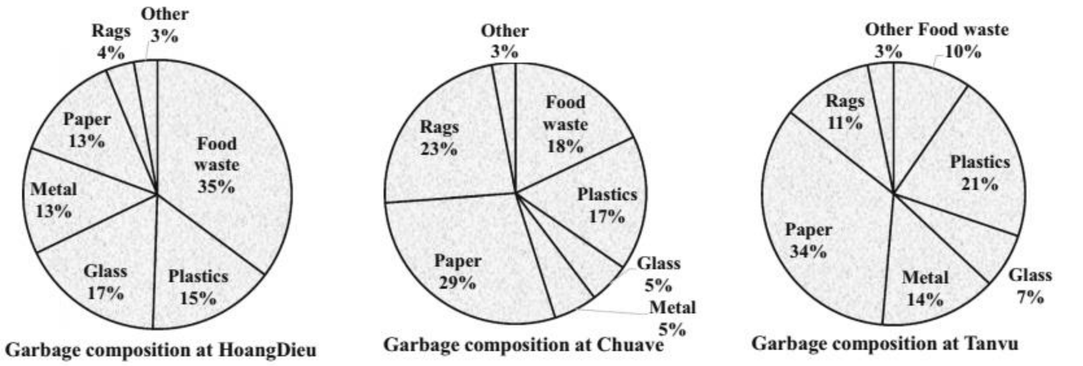


Figure 3-3. Garbage composition by weight

According to Figure 3-2, while the food waste fraction was highest in ship-garbage at HoangDieu port (for bulk ships) (35 %), the largest ship-garbage component was paper in both Chuave and Tanvu ports (for container ships), 29 and 34 %, respectively. At Tanvu port, the food waste fraction was only 10 % of the total garbage quantity. It was found that the rag fraction was around 4 % at HoangDieu port, while a larger portion of this waste was recorded in Chuave port, at 23 %, and Tanvu port, at 11 %. The plastic fraction of the ship-garbage ranged from 15 to 21 %. It consisted mostly of packaging materials and plastics bags. The glass fraction, such as glass bottles and broken lamps, varied from 5 to 17 %, while metal accounted for 5 to 13 % of the total amount of garbage. Some hazardous items were also detected within the collected garbage, for example, oily rags, paint boxes, and fluorescent lamps. Other waste amounted to 3 % of the total garbage, which included wood, styrofoam, and rubber.

Results from the survey show that some hazardous items to environment were detected in the collected ship-generated garbage, for example, oily rags, paint boxes, and fluorescent lamps. The survey identified that the largest amount of received ship-garbage was at Tanvu port: almost 1160 kg during an 18-day period, while 23% of waste in Chuave port was rags. Most of the rags at these ports were contaminated by oil, so it is considered as hazardous waste. Moreover, high percentage of burnable materials (papers, plastics, food waste) were included in non-hazardous waste. Therefore, storage at port and on ship should be considered as places with high risk of fire accidents.

3.3.1.2. Review on environmental conditions at Haiphong ports

Several studies have reported the environmental issues at Haiphong ports. Report on Port environment (Vietnam Maritime University, 2012) provided data on emission (TSP, CO, SO_2, NO_2), wastewater, noise in Haiphong port. In 2011, concentration of TSP and NO_2, and noise at Haiphong port exceeded Vietnamese standards QCVN 05:2013/BTNMT. Table 3-4 summarizes main findings from the report of Vietnam Maritime University about environmental condition at ports in Haiphong city.

Table 3-4: Summary of environmental condition at port areas of Haiphong city

City	Total Ship calls	Emission				Wastewater *(m^3/year)*	Noise *(dBA)*
		TSP *(mg/m^3)*	SO_2 *(mg/m^3)*	NO_2 *(mg/m^3)*	CO *(mg/m^3)*		
Haiphong	16702 *(in 2011)*	0.26-0.46	0.11 – 0.17	0.12 – 0.22	2.16 – 3.01	33403	68.9-79.6
Standard QCVN 05:2013/BTNMT		0.3	0.35	0.2	30		70

Source : Vietnam Maritime University, 2012

Other report from Lan, Trang, Nghi, & Huong (2013) also raised issues on air quality at three port areas of Haiphong city. Level of PM_{10} in Hoang Dieu, Chua Ve, and Tan Vu ports are on average 142 $\mu g/m^3$, 136 $\mu g/m^3$, and 141 $\mu g/m^3$ per day respectively that much higher than the standard recommended by the WHO is 50 $\mu g/m^3$ per day.

Report from the Institute of Marine Environment and Resources on issues of integrated management for the port environment in Hai Phong toward green and blue ports (2015) estimates that wastewater with oil in port activities in Haiphong city result in 3000 to 5000 tonnes annually.

Another study of green growth in Haiphong city by Organisation for Economic Co-operation and Development (OECD, 2016) raises issue on solid waste from shipping activities as a growing problem. The study also mentions unregulated and uncontrolled ship-generated waste at port increasing the vulnerability in Haiphong city. Our survey on garbage quantity and composition (To & Kato, 2017) also provides key information about characteristic of solid waste from docking ships at HoangDieu, Chuave and Tanvu ports. Both of non-hazardous and hazardous waste was found in ship-garbage. For solid waste from port operation, the Haiphong port company estimated and reported quantity from daily activities at three port areas in Table 3-5.

Table 3-5: Port-generated solid waste

Port areas	**Solid waste**	
	Non-hazardous waste *(kg/year)*	Hazardous waste *(kg/year)*
HoangDieu	39616	4320
Chuave	45320	5300
Tanvu	46071	2000

From above data on environmental conditions at ports, main environmental hazards from normal activities of ships and ports in Haiphong include “emission”, “wastewater”, “non-hazardous waste”, “hazardous waste”, and “noise”.

3.3.1.3. Review on recent incidents at Haiphong ports

The fire of 2/10 phosphorus containers occurred on August 17, 2013 on a container ship name “RBD BORIA of the French Republic” which was carrying 700 other containers at the transfer area of Lach Huyen, Hai Phong. Because there were no fire-fighting ships on the sea, the authorities decided to tow the ship to Got dock (Cat Hai) to control the fire.

The spill of 300 tons of Linear Ankyl Benzen (LAB) occurred at CuaCam port in Hai Phong due to a broken pipeline on November 19, 2015 and polluted the Northeast Canal of Haiphong city.

On November 27, 2015, 24 tons out of 480 tons of phosphorus on the Contship Ace ship was burned in Nam Hai port. Since this was fire of phosphorus, a large amount of toxic emission was emitted into the environment

Fire accident occurred on March 10, 2018 from the "Hai Ha 18" ship in port areas of Haiphong. Fire occurred at the pumping system of the engine room during cargo transfer of petroleum.

The statistical data from Maritime administration of Haiphong provides the numbers of ship accidents occurred in port areas of Haiphong. There were 6 cases of ship accidents in 2015, 5 cases in 2016 and 5 cases in 2017.

According to above historical data, environmental hazards related to incidents at port areas in Haiphong city include "fire", "ship accidents", "oil spills", and "chemical accidents".

3.3.2. Developing hierarchical structures for emergency issues

3.3.2.1. Environmental emergency

The hierarchical structure for environmental emergency at port areas is shown in Figure 3-4.

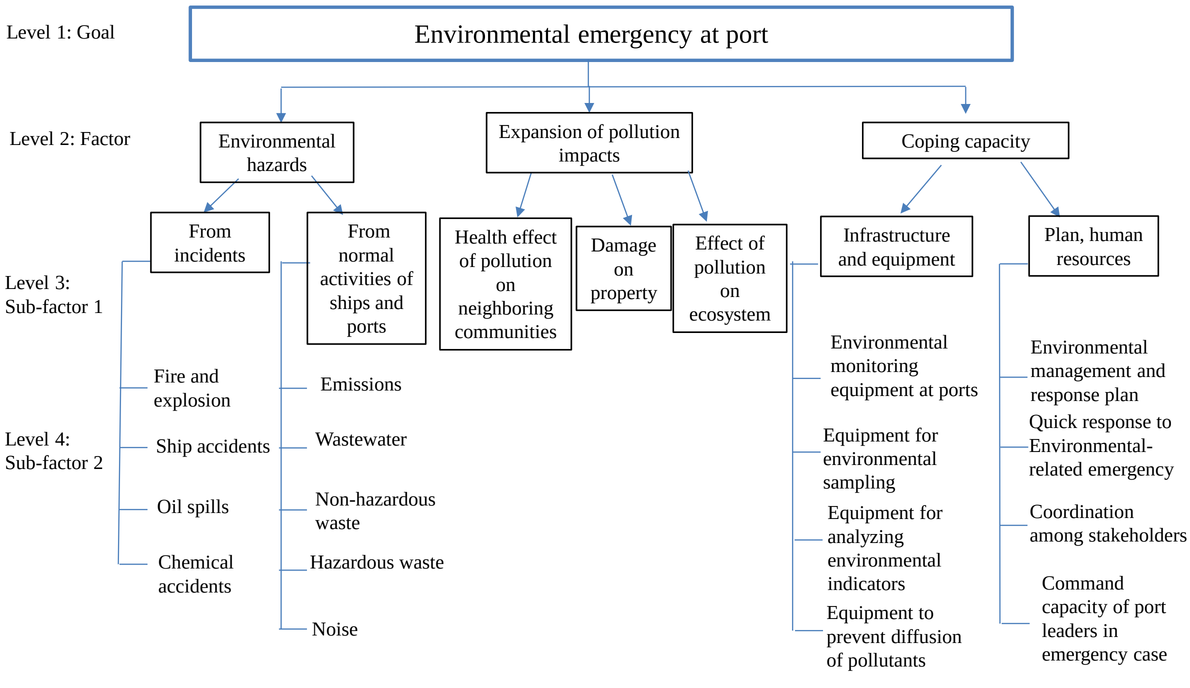


Figure 3-4. Hierarchical structure for environmental emergency

- Level 1: Goal is defined according to the target of developing the hierarchical structure for understanding environmental emergency at port areas.

- Level 2: Factors are developed by referring to the three components of risk: Hazard, Vulnerability and Capacity. These components are more specified by (Schmidt-Thomé, Kallio, Greiving, & Fleischhauer, 2003) who mentions three components as hazard potential, damage potential, and coping capacity. For level 2, the three factors are “Environmental hazards”, “Expansion of pollution impacts”, and “Coping capacity”. Each factor has sub-factors at level 3 and level 4 of the hierarchical structure.

- Sub factors of “Environmental hazards” (level 3 and level 4): environmental incidents and normal activities of ships and ports are two main sources of environmental hazards in Haiphong port areas. As using results of above sections, four sub-factors of environmental hazards from incidents including fire and explosion, ship accidents, oil spills, and chemical accidents. Five sub-factors related to environmental hazards from normal activities of ship and port are emission, wastewater, non-hazardous waste, hazardous waste and noise.

- Sub-factors of “Expansion of pollution impacts” (level 3): Ronza, Lázaro-Touza, Carol, & Casal (2009) presented a review of the damages derived from environmental issues and accidents in port areas. Firstly, pollutants affect the human health to whom live nearby port areas. Also, the economic damage comprises of loss of profit and material to recovery pollutants. Equally important, ports are usually situated on a seacoast that have high risk to affect surrounding ecosystem. Pollutants from port and ship operation cause biodiversity damage (Walker et al., 2019). In the hierarchical structure, the three sub factors of “Expansion of pollution impacts” are health effect of pollution on neighbouring communities, damage on property, and effects of pollution on the ecosystem.

- Sub-factors of “Coping capacity” (level 3, level 4): As definition by United Nation office for Disaster risk reduction (UNISDR), Coping capacity is the ability of people, organizations and systems, using available skills and resources, to manage adverse conditions, risk or disasters (“Terminology on Disaster Risk Reduction,” 2017). Coping capacity includes resources such as infrastructure and equipment, and the skill of people to prevent, respond and recover from risk or disasters. Coping capacity is divided into two sub factors at level 3: Infrastructure and equipment, and plan and human resources.

- Regarding to infrastructure and equipment at port areas to cope with environmental issues, two important tasks for responders are to identify current situations and prevent diffusion of pollutants. The environmental monitoring program mentioned its core action is to capture situations of all the activities at port areas

(*Environmental, Health, and Safety Guidelines for Ports, Harbors, and Terminals*, 2017). To monitor environmental criteria, it is necessary to have equipment and tools to monitor, sample and analyze environmental criteria at ports. These facilities are necessary for coping with environmental issues. I propose four sub factors at level 4 for "infrastructure and equipment" including: monitoring equipment at port, equipment for environmental sampling, equipment for analysing environmental factors, and equipment to prevent diffusion of pollutants.

- Regarding to plan and human resources at port areas, every port has to make an environmental management plan for responding to environmental issues according to the Law on Natural Resources and Environment of Sea and Islands (*No. 82/2015/QH13*, 2015). Moreover, command and control, and coordination among stakeholders are functions that are mentioned in the international standard ISO 22320, 2011 on the capabilities of organizations to respond to incidents. For emergency cases, quick response to environmental issues is necessary to reduce damage from pollutions. In summary, four sub factors at level 4 for "plan and human resources" are environmental management and response plan, quick response to environmental related emergency, coordination among stakeholders, and command capacity of port leaders in emergency cases.

3.3.2.2. Fire-related emergency

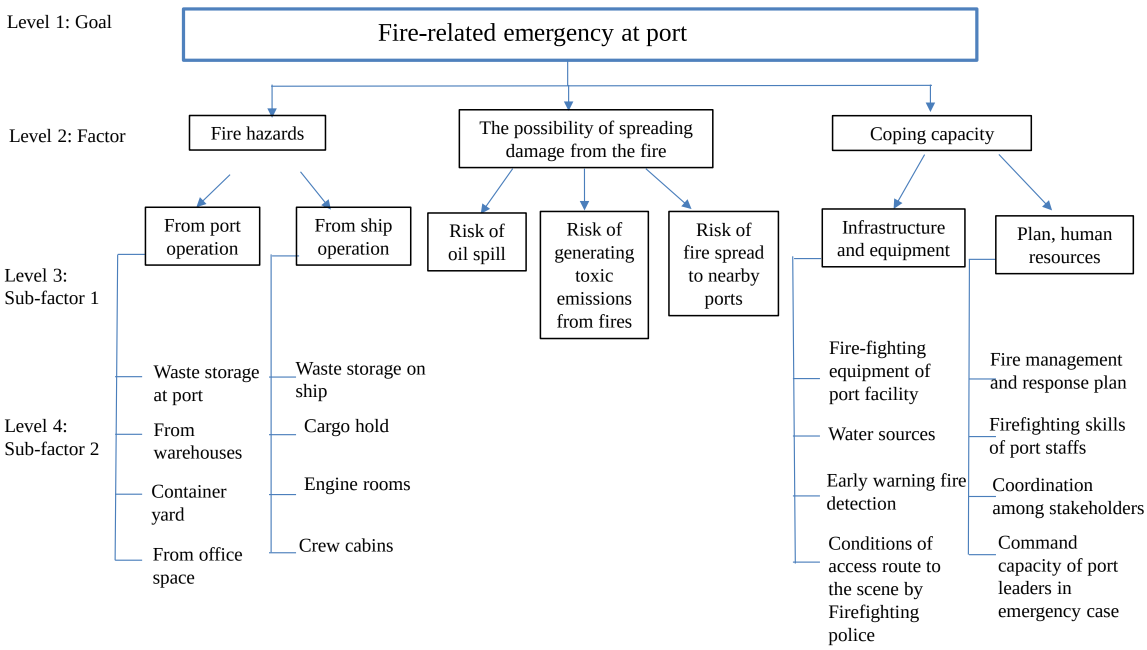


Figure 3-5. Hierarchical structure for Fire-related emergency

- Level 1: Goal is defined according to the target of developing the hierarchical structure for understanding fire-related emergency at port areas.

- Level 2: Factors were developed by referring to three components of risk: Hazard, Vulnerability and Capacity. These components were more specified by (Schmidt-Thomé et al., 2003) who mentions the three components as hazard potential, damage potential, and coping capacity. For level 2, the three factors are “Fire hazards”, “Possibility of spreading damage from the fire”, and “Coping capacity”. Each factor has sub-factors at level 3 and level 4 of the hierarchical structure.

- Sub factors of “Fire hazards” (level 3 and level 4): Fire accidents at Haiphong ports can occur from port operation or ship operation. Level 3 of fire hazards is divided into two sources of fire accidents: from port operation, and from ship operation. Risk of fire accident from Haiphong port is found from the drill plan (*Exercise plan for firefighting at Haiphong port*, 2013) for responding to fire accidents. Under Law on Fire Prevention and Fighting (*No. 40/2013/QH13*, 2013), port facilities have to do drill for addressing with fire accidents at their own facilities. For Haiphong port, several places are in high risk of fire and explosion including warehouses, container yards, and office spaces. Moreover, the survey on ship-garbage at Haiphong port found that ship-garbage includes high percentage of burnable materials (To & Kato, 2017), that are stored at port before moving to landfill. As Figure 3.2 shows food waste, paper, plastics, and rags are counted for 87% at Chuave terminal, that can be burned without proper storage at port areas. Therefore, level 4 of sub-factors related to fire hazards from port operation include waste storage at port, warehouse, container yard, and office space. Regarding fire hazards from ship operations, there were four fire accidents that occurred from ships at ports in Haiphong from 2015-2018 as statistics of Haiphong Port Authority. One fire accident occurred on November 27, 2015 from a cargo hold of the “Contship Ace” ship docked in Nam Hai port. Another big fire accident in another port in Haiphong occurred on March 10, 2018 from the “Hai Ha 18” ship. Fire occurred at the pumping system of the engine room during cargo transfer of petroleum. From these accidents, we defined cargo hold and engine room as places with high risk of fire. Moreover, waste storage on ship is one place with a high risk of fire because of the high percentage of burnable materials in garbage composition. Crew cabins on the ship is another place to be considered in fire prevention and response. Four places at level 4 of sub-factors related to fire hazards from ship operation: waste storage on ship, cargo hold, engine rooms, and crew cabins.

- Sub factors of "the possibility of spreading damage from the fire" (level 3): Fire can extend to more complicated accidents at port areas. Fire, explosion, oil spill and toxic release are relevant problems during emergency cases at port areas (Mohee, Surroop, Mudhoo, & Rughooputh, 2012). In Haiphong city, practical firefighting activities are also related to prevent oil spill and toxic gas from a fire. For example, leaders from Haiphong city during a response to a fire accident on Hai Ha 18 ship requested other forces to prevent and ready in case of oil spill, as well as fire expanding to nearby port facilities. Because of toxic emissions from fire, more than 50 firefighters needed to be hospitalized after firefighting at Nam Hai port on November 27, 2015. In the hierarchical structure, three sub factors at level 3 of "the possibility of spreading damage from the fire" are risk of oil spill, risk of generating toxic emissions from fires, and risk of fire spread to nearby ports.

- Sub-factors of "Coping capacity" (level 3, level 4): I divide two sub-factors for level 3 of coping capacity in fire-related emergency issues that are the same as the idea of environmental emergency issues. Regarding infrastructure and equipment at port areas to cope with fire, the Law on Fire Prevention and Fighting (*No. 40/2013/QH13*, 2013) specifies that all of the companies and local organizations need to prepare and firstly response to fire before professional forces like firefighting police arrive to the emergency field. Therefore, firefighting equipment of port facilities, and early warning fire detection are important facilities for first response to fire accident. Moreover, in the drill plan for HoangDieu port, water sources and conditions of access route to the scene by firefighting police are two main conditions that related to firefighting activities. These conditions also are mentioned in other drill plan of firefighting polices. I propose four sub factors at level 4 for "infrastructure and equipment" for fire-related issues including: firefighting equipment of port facility, water sources, early warning fire detection, and condition of access route to the scene by firefighting police.

- Regarding to plan and human resources at port areas, a management and response plan is necessary as a base to control and respond to fire that is also required in the Law on Fire Prevention and Fighting (*No. 40/2013/QH13*, 2013). Command and control, and coordination among stakeholders are functions that are mentioned in the international standard ISO 22320, 2011 on the capabilities of organizations to respond to incidents. In fire accidents, the firefighting skill of port staff is necessary to extinguish the fire as soon as possible before professional forces arrives. At level 4 for "plan and human resources", four sub-factors are proposed: fire management and response plan, firefighting skills of port staffs, coordination among stakeholders, and command capacity of port leaders in emergency cases.

3.3.3. Questionnaire survey

Three interviewees from each emergency field were interviewed in Haiphong city to collect their judgments. For environmental group, three interviewees are one manager on safety division of Haiphong port, one director of environmental center of Vietnam Maritime University, and one officer of Haiphong Department of Natural resources and environment (Haiphong DONRE). For firefighting issues, three officers of Haiphong firefighting police answered questionnaire. Two separated questionnaires were used that included pairwise comparisons of all individual factors and sub-factors. To help interviewees have more information to select their answers, port facilities (Port capacity, equipment, type of ship and cargo, storage facilities) and results on solid waste quantity and composition in HoangDieu, Chuave, and Tanvu ports (described in section 3.3.1.1) were provided to them during interview.

An example of the pairwise comparison in the questionnaire is provided in Figure 3-6. Participants were asked to select the relative importance of two options.

With respect to **GOAL: Environmental emergency risk at port**,
Using the scale from 1 to 9 (where 9 is extremely and 1 is equally important),
please indicate (X) the relative importance of options **A** (left column) to options **B** (right column).

A Options	Extremely		Very Strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very Strongly		Extremely	**B Options**
Environmental hazards	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Expansion of pollution impacts
Environmental hazards	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Coping capacity
Expansion of pollution impacts	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Coping capacity

Figure 3-6. Question with respect to Environmental emergency at port

3.3.4. AHP data analysis

Based on the Hierarchical structures for emergency areas, goal, factors and sub-factors were constructed in the Super Decision software. Nodes and their relationships are shown in Figure 3-7 and 3-8.

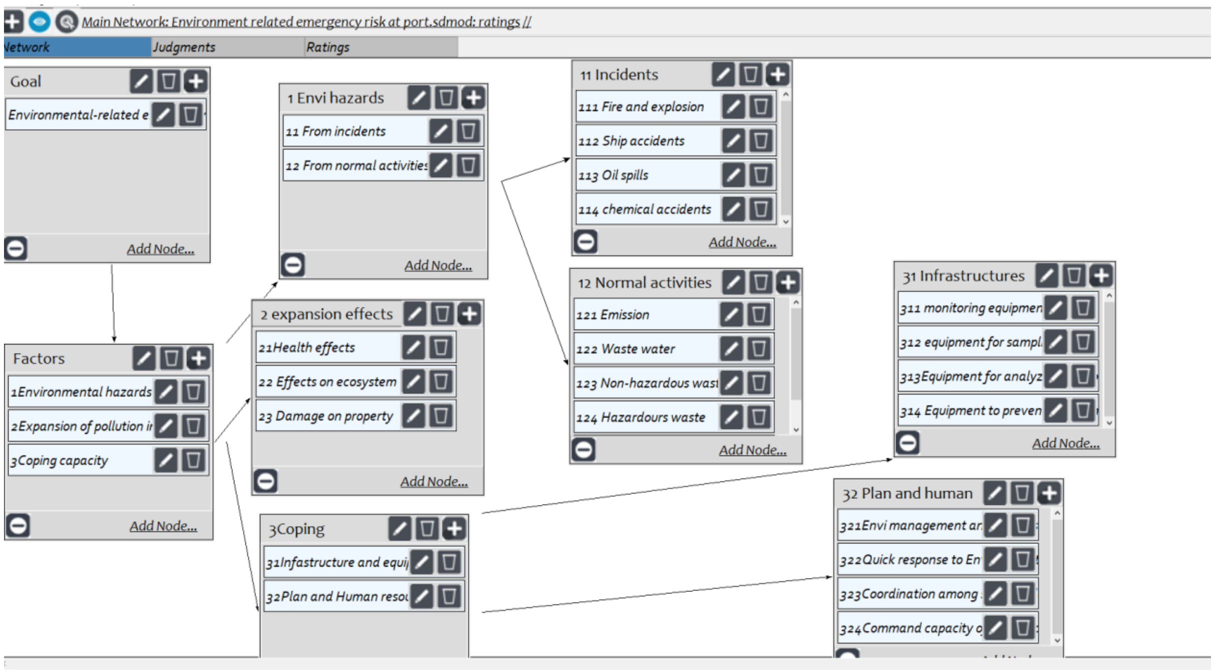


Figure 3-7. Nodes for environmental emergency

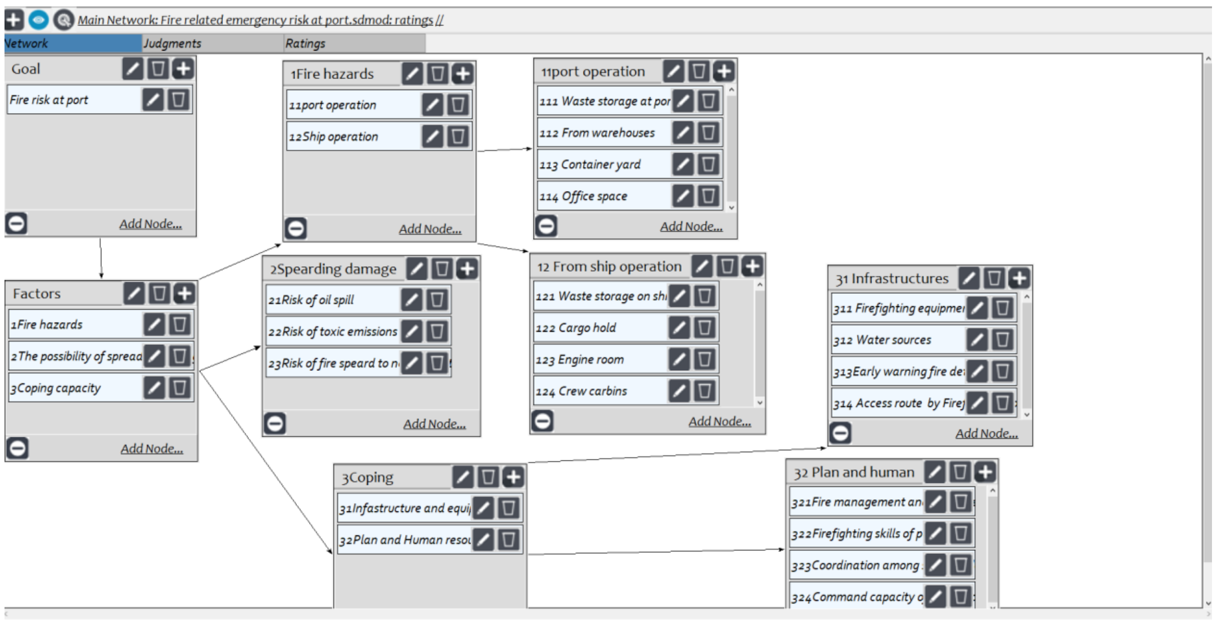


Figure 3-8. Nodes for fire related emergency

Data from the questionnaire surveys in step 2 were inputted in the Judgments function of the software. The calculation shows results from the normalized weight of each factor and sub factor, as well checking the inconsistency of node comparisons. An example of the result is shown in Figure 3-9. In the example, the value of CR is 0.052 (less than 0.1) so that the consistency of the answer is acceptable.

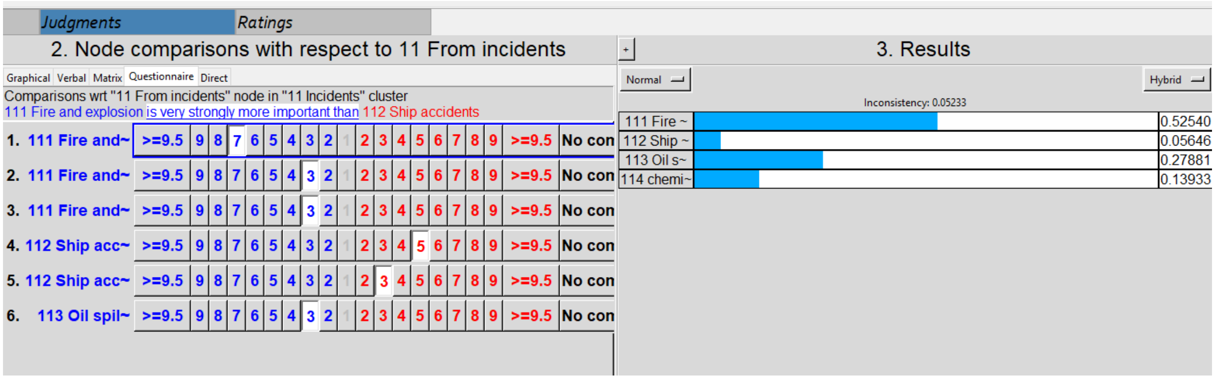


Figure 3-9. An example of AHP calculation in Super Decision software

3.3.5. Combining and interpreting results

A summary of the results for the normalized weight by the environmental group is shown in Table 3-6. WAMM was calculated to identify the priority elements. It is noted that if the consistency ratio of a node comparison is more than 10%, results of the weight for that comparison is removed from the calculation of WAMM. Priority factors or sub-factors were defined with the highest value of mean in each comparison. Applying the same approach, Table 3-7 shows result of fire related emergency in the port area.

Table 3-6: AHP analysis for environmental emergency

Factors/sub-factors	Normalized Weight by Expert 1	Normalized Weight by Expert 2	Normalized Weight by Expert 3	Weighted arithmetic mean
1 Environmental hazards	0.09	0.12	0.33	0.18
2 Expansion of pollution impacts	0.09	0.13	0.33	0.19
3 Coping capacity	0.82	0.75	0.33	**0.63**
11 From incident	0.83	0.83	0.90	**0.86**
12 From normal activities	0.17	0.17	0.10	0.14
21 Health effects	0.26	0.43	0.71(*)	0.34
22 Effects on ecosystem	0.64	0.43	0.22(*)	**0.53**
23 Damage on property	0.10	0.14	0.07(*)	0.12
31 Infrastructure and equipment	0.75	0.13	0.50	0.46
32 Plan and Human resources	0.25	0.88	0.50	**0.54**
111 Fire and explosion	0.53	0.21	0.14	0.29

Factors/sub-factors	Normalized Weight by Expert 1	Normalized Weight by Expert 2	Normalized Weight by Expert 3	Weighted arithmetic mean
112 Ship accidents	0.06	0.06	0.06	0.06
113 Oil spills	0.28	0.61	0.55	**0.48**
114 Chemical accidents	0.14	0.11	0.24	0.17
121 Emission	0.18	0.14	0.06	0.12
122 Waste water	0.46	0.16	0.37	0.33
123 Non-hazardous waste	0.10	0.04	0.06	0.07
124 Hazardous waste	0.20	0.62	0.40	**0.41**
125 Noise	0.06	0.04	0.11	0.07
311 Monitoring equipment	0.62	0.57	0.14	**0.45**
312 Equipment for sampling	0.15	0.08	0.06	0.10
313 Equipment for analyzing environmental indicators	0.15	0.08	0.06	0.10
314 Equipment to prevent diffusion of pollutants	0.07	0.28	0.74	0.36
321 Envi management and response plan	0.06	0.09	0.25	0.13
322 Quick response to Environmental-related emergency	0.26	0.09	0.25	0.20
323 Coordination among stakeholders	0.57	0.61	0.25	**0.48**
324 Command capacity of port leaders in emergency case	0.12	0.21	0.25	0.19

Note: (*) consistency ratio > 10%, bold font numbers show the highest value of mean

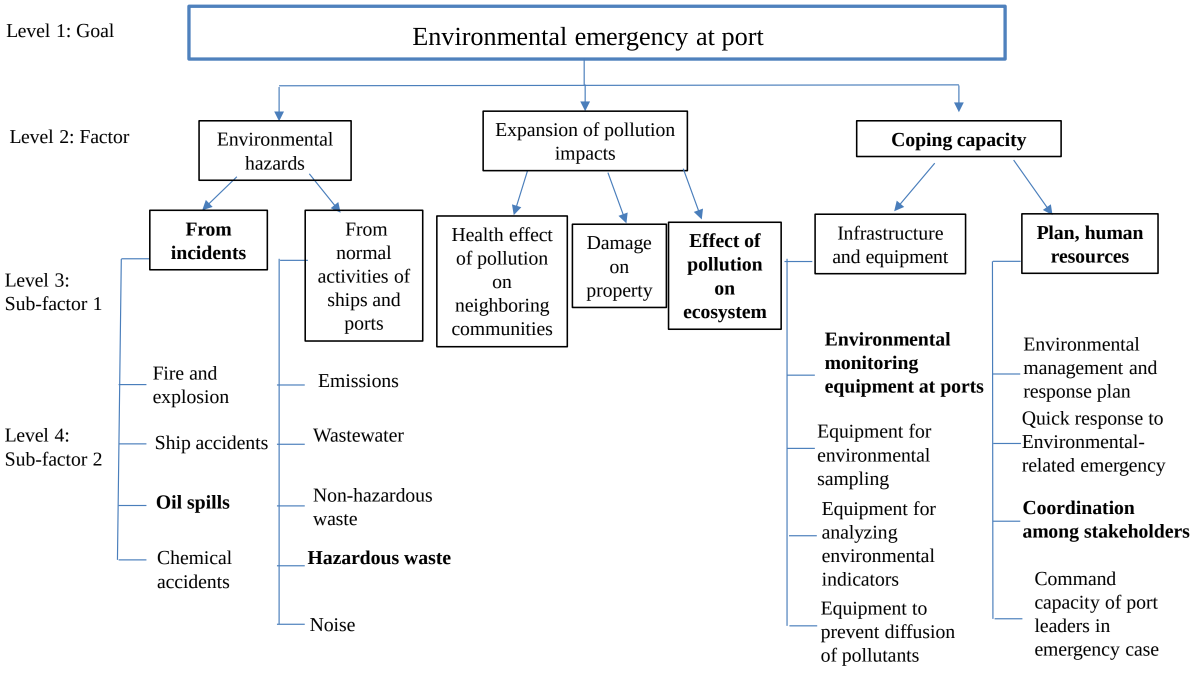
Table 3-7: AHP analysis for fire-related emergency

Factors	Normalized Weight by Expert 1	Normalized Weight by Expert 2	Normalized Weight by Expert 3	Weighted arithmetic mean
1 Fire hazards	0.57	0.22(*)	0.64	**0.61**
2 The possibility of spreading damage from the fire	0.07	0.07(*)	0.10	0.08
3 Coping capacity	0.36	0.71(*)	0.26	0.31
11 Port operation	0.17	0.17	0.17	0.17
12 Ship operation	0.83	0.83	0.83	**0.83**
21 Risk of oil spill	0.17	0.52(*)	0.08	0.12
22 Risk of toxic emissions	0.75	0.18(*)	0.49	**0.62**
23 Risk of fire spread to nearby ports	0.08	0.30(*)	0.44	0.26

Factors	Normalized Weight by Expert 1	Normalized Weight by Expert 2	Normalized Weight by Expert 3	Weighted arithmetic mean
31 Infrastructure and equipment	0.50	0.75	0.50	**0.58**
32 Plan and Human resources	0.50	0.25	0.50	0.42
111 Waste storage at port	0.12	0.09	0.32	0.17
112 From warehouses	0.55	0.35	0.54	**0.48**
113 Container yard	0.05	0.51	0.10	0.22
114 Office space	0.28	0.05	0.05	0.13
121 Waste storage on ship	0.11(*)	0.14	0.14	0.14
122 Cargo hold	0.05(*)	0.12	0.37	0.24
123 Engine room	0.55(*)	0.69	0.44	**0.57**
124 Crew cabins	0.29(*)	0.05	0.05	0.05
311 Firefighting equipment of port	0.05	0.05	0.30	0.13
312 Water sources	0.11	0.05	0.06	0.07
313 Early warning fire detection	0.54	0.70	0.22	**0.49**
314 Access route by Firefighting police	0.30	0.19	0.42	0.30
321 Fire management and response plan	0.29	0.27	0.06	0.21
322 Firefighting skills of port staffs	0.05	0.04	0.30	0.13
323 Coordination among stakeholders	0.11	0.59	0.43	**0.38**
324 Command capacity of port leaders in emergency case	0.54	0.09	0.20	0.28

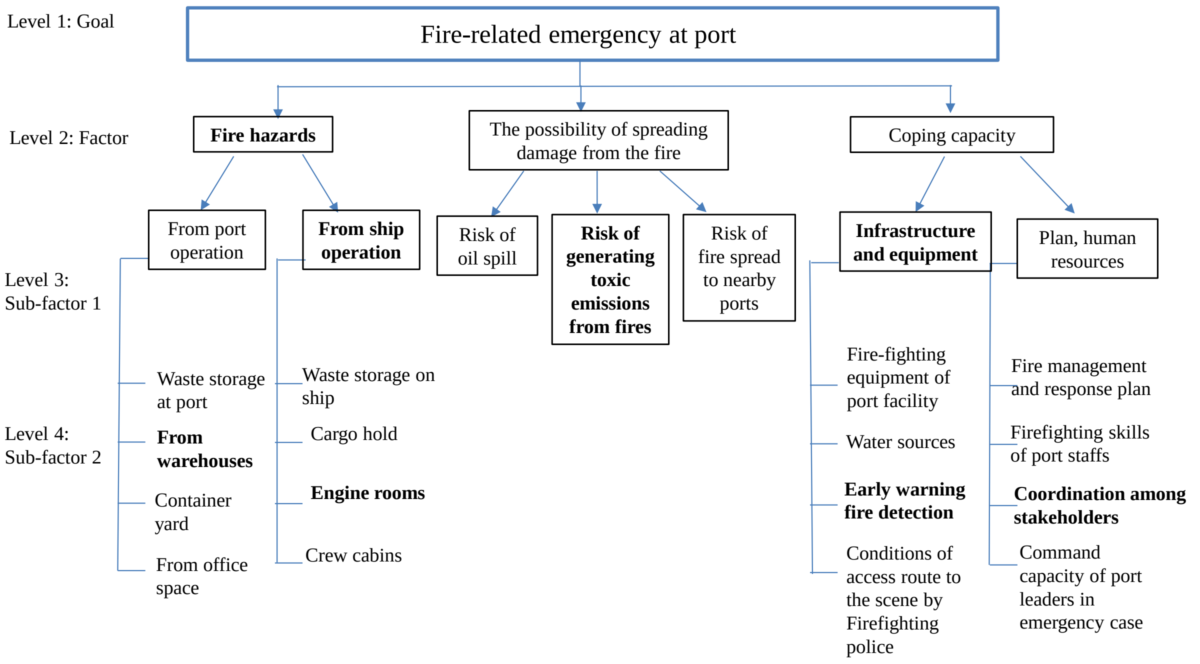
Note: (*) consistency ratio > 10%, bold font numbers show the highest value of mean

To better understand the results of the AHP analysis, I highlight key elements that have the highest weighted arithmetic mean in each node comparison. Figure 3-10 and Figure 3-11 show key elements for each emergency area in the hierarchical structures.



Note: Bold font text show key elements

Figure 3-10. Key elements in environmental emergency



Note: Bold font text show key elements

Figure 3-11. Key elements in Fire-related emergency

As Figure 3-10 states, the most important line of attention of environmental group is as follows: Environmental emergency → Factor: coping capacity → sub-factor 1: plan, human resources → sub-factor 2: coordination among stakeholders. Experts in the environmental field prefer to enhance the coping capacity to reduce environmental emergency at port. To enhance the coping capacity, they considered planning and human resources, and coordination among stakeholders. Responding to environmental issues need to encourage participants from many organizations. Although there are requirements from national laws to conduct plans and drills for training with stakeholders in case of a natural disaster or fire and oil spill, a comprehensive environmental emergency response plan is still lacking at port areas. Moreover, they have not yet conducted table-top or functional exercises to enhance communication and coordination among stakeholders. Other highlighted sub-factor related to the coping capacity is an environmental monitoring system at port. Comparing incidents and the normal activities of ships and ports, interviewed group considered incidents as the main source of emitting environmental hazards that require emergency response in port areas, especially oil spills. The normal activity of ships and ports might cause some environmental problems, but it is rare for them to become emergency cases at port, excluding cases of illegally discharged hazardous waste. Since ports are located near the sea and river, environmental group emphasized the effect of pollution on the ecosystem.

Regarding the fire-related emergency in port areas, the most important line after the Goal in Figure 3-11 is from Factor: Fire hazards→Sub-factor 1: Ship operation → Sub-factor 2: Engine rooms. Experts in firefighting police prefer to reduce fire-related emergency by controlling fire hazards. This result is suitable with the principle of firefighting and prevention that is mention in the Law on Fire Prevention and Fighting No. 40/2013/QH13 (2013). Article 4 of the Law specifies fire prevention is a priority for this area by controlling fire hazards. Moreover, experts of firefighting police selected engine rooms on the ship as places that have to be controlled to prevent fire. It reflects the fact that recently two of the largest fire accidents at ports in Haiphong occurred from ships. Engine rooms are connected to oil tank and are at high risk of explosion in fire cases. One fire accident occurred from a container ship on the 27th of November 2015 while another occurred from a tank ship on the 10th March 2018. Many firefighters were poisoned by toxic emission during the firefighting. That is one of the reason why experts chose toxic emission as an issue of spreading damages during a fire. Early warning fire detection and coordination among stakeholders are key sub-factors were focused.

By comparing the key issues of environmental and fire-related emergency, there are similarities among experts to focus on coordination among stakeholders and equipment to warn or monitor situations at port. These sub-factors are related to the coping capacity in port areas. Results reveal that collecting and sharing timely information among stakeholders during emergency cases at port are very important issues.

3.4. Summary of Chapter 3

Five steps of the procedure to apply AHP method for choosing exercise topics have been proposed. The procedure then has been tested in two case studies on environmental and fire-related emergency at Haiphong ports.

As the first step, environmental hazards at Haiphong ports have been investigated through field survey, literature and historical review. We identified two sources of hazards at Haiphong ports: normal activities of ships and ports, and incidents. A field survey on ship-garbage quantity and composition at three ports in Haiphong city provided data related to both hazardous and non-hazardous waste. Oily rags, paint boxes and fluorescent lamps were found from garbage discharged from these ports. It is also high risk of fire accident from high percentage of burnable materials in non-hazardous waste. Review on data about environmental conditions at ports in Haiphong city added other hazards including emissions, wastewater, and noise from port operation. From records of incident occurred at port areas in Haiphong, environmental hazards related to incidents include fire, ship accidents, oil spills, and chemical accidents.

In the second step, the hierarchical structures have been created for both environmental emergency and fire-related emergency at Haiphong ports. Results from hazards identification contributed to make appropriate elements in the hierarchical structures. In the third step, questionnaire surveys have been conducted to collect opinions of two expert groups. Some detail information on port facilities and solid waste quantity and composition were provided to interviewees during the survey. After that, normalized weight of factors and sub-factors were calculated, and combined by weighted arithmetic mean for each group, and tested in two case studies. Highlights of the highest normalized weights in the same factor level provided key elements for choosing emergency exercise topics. Application of AHP method in this chapter help us to point out appropriate topics for emergency exercises at Haiphong ports.

4. UNDERSTANDING COMMUNICATION STRUCTURE AMONG STAKEHOLDERS THROUGH TABLE-TOP EXERCISE

4.1. Introduction

There are close relationship between communications and emergency management. Emergency management has four phases including mitigation, preparedness, response, and recovery. Meanwhile, communication plays important roles in all four phases. When emergency responders develop their communication networks, increase discussion and share ideas, they make efforts to enhance mitigation (McEntire, 2007, p. 274). In the preparedness phase, effective public communication program could overcome apathy including a lack of awareness, social pressure and difficult explaining the benefits of preparedness (Der Heide & Irwin, 1989). Regarding the third phase, response activities require accurate and timely communication among responders and organizations, that have been critical considered in a number of literatures (Der Heide & Irwin, 1989; Drabek & McEntire, 2002; Toulmin, Givans, & Steel, 1989). There is a considerable increase tasks of communications and information flow in emergencies (Rosenthal, Charles, Hart, Kouzmin, & Jarman, 1989). In recovery phase, communications problems from difference of social and cultural groups caused difficulty to provide aids and health supports for community (Anderson, Fornell, & Lehmann, 1994; Hille & Phillips, 1996). Therefore, understanding communications among stakeholders is important for organizations.

Emergency response system consists of a multi participant system with different stakeholders, teams or people who have important roles to success respond an emergency. In many settings, these teams are formed on an ad-hoc basis and work together only when responding to events. Moreover, differences on specialisation, geographically among stakeholders are other issues related communication and coordination. While characteristics of emergencies include uncertainty, information, time pressures and dynamic (Brehmer, 1996; Flin, 1996), high risks of individual errors and inadequate team competencies during emergencies. Individual errors include inadequate situation assessment, poor response skills, inappropriate decision making, whereas teamwork errors include lack of explicit communication and coordination (Rouse, Cannon-Bowers, & Salas, 1992). Therefore, it is high demand of classifying relationship and communication structure among stakeholders in emergency management.

Training and exercise are used to better preparedness for stakeholders before emergencies. Different types of exercise such as seminar, table-top exercise (TTX), drills, functional exercise, full-scale exercise should be applied by considering both organizational capability and targets of trainings. Regardless types of exercise, much of information can obtained after conducting exercise. Table-top exercise (TTX), as the most common discussion-based exercise, provides environment to discuss and share knowledge related to roles, procedures, or the responsibilities of stakeholders (Canton, 2007, p. 121). Therefore, it is possibility to extract information that is collected during TTX for understanding relationship and communication structures among stakeholders.

In this chapter, research focus is to understand relationship and communication structures among stakeholders in emergency issues through developing and extracting data from TTXs. In next section, different perspectives on communication structures are discussed, then two methods to collect data on communication structures in TTX are proposed. Two methods are applied for two case studies of TTXs in Haiphong city Vietnam. Depending on obtained data, different techniques to interpret data are applied for better understanding relationship and communication structures among stakeholders.

4.2. Methodology

4.2.1. Data collection methods

Communication structure refers as how information is passed among stakeholders. However, watching how responders in organizations communicate and how information is transmitted among stakeholders is difficult tasks (Papa, Daniels, & Spiker, 2007). Two perspectives of organizational communication structure are existed among scholars that are relevant to methods to define communication structure. The first perspective is the perceived communication relationship among people. In this perspective, some scholars have applied method to ascertain communication structure by asking or interviewing organizational members. In particular, stakeholders in specific areas are asked to explain how they pass on information to others. The second prominent perspective of organizational communication structure is the observable communication perspective. In this perspective, method to understand communication structure is literally observe what actually happens among stakeholders.

Since two methods are relevant to two perspectives, I need to consider about these perspectives. There are number of discussion about differences between two perspectives. A series of studies by Bernard, Killworth, & Sailer (1979) argued that using participant self-report does not yield valid measure of communication that should be better to observe network by independent coders. On the other side, Burt and Bittner, (1981) and Kimball Romney & Weller (1984) argued that methods of modelling perceptual data yield better correspondence to structure in observable interaction that above studies. Some other groups have ceded the claim that perceptual data do not measure observable communication. They argued for studying perceived links as distinct phenomena (Bullis & Bach, 1991; Monge, 1987).

To address the contradiction between two perspectives, Corman & Scott, (1994) developed model to show relationship and mediating processes between perceived and observable communication behaviour. They applied a situationalist approach to overcome this contradiction. Figure 4-1 shows distinction between the perceived network links in the domain of social relations and situated communication behaviour in the domain of social interaction.

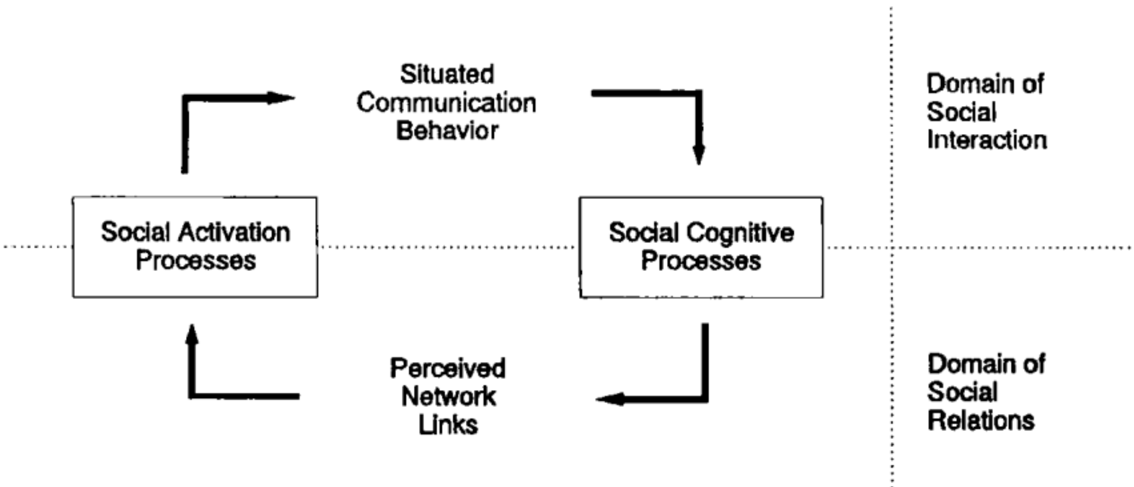


Figure 4-1. Relationship between perceived and observable communication.

Source: Corman, S. R., & Scott, C. R. (1994), Figure 1

In the domain of social relations, perceived communication is generated from social cognitive processes. Social cognitive processes are related personal experience, formal and informal collective understandings for communication. Perceived communication data from self-reports reflects information from social cognitive processes such as what they have learnt from rules, their knowledge and experiences. Perceived communication become manifest during activation processes. In the domain of social interaction, situated communication behaviour of individuals and groups can be observed. Observable communication data reflects communication behaviour in specific situations. Therefore, applied methods for understanding communication structure are depended on which domain of social network in research activities. If researchers aim to find communication structure in the domain of social relations, for example survey on relationship among stakeholders related to legislations, rules and individual experiences, methods on the perceived communication perspective should be applied. On the other hand, studies on communication structure in the domain of social interaction should be examined by observing activities of stakeholders.

The first factor affects to how researchers select methods for data collection is the perspectives of organizational communication structure. Data-collection method is related to the domain of social process that researcher aims to study from exercise data. In TTX, if researcher would like to define relationship among stakeholders in the domain of social relations, for example rules, formal and informal communication structure or human experiences, they can consider to collect perceived communication data. I call the exercise can serve this research objective is rule-based event. Asking participants during this event is one way to collect perceived communication data as above discussions. Other researchers can focus on the domain of social interaction for defining relationship or communication structure among stakeholders in TTX. Data related to how participants actually interact with each other in specify situations of exercise should be collected in the observable communication perspective. Behaviour-based event can serve this objective of researchers. Methods to observe behaviour and action of people are necessary in the behaviour-based event.

Another factor related methods to collect communication data is sources of information. There are different methods whether if information is obtained from individuals or groups. Several methods of data collection for individually oriented methods includes interview, instruments or tests. The interview is one of the most commonly used methods for gathering data when data collector asks the interviewees by specific questions. Information to be shared in individual interview is of a personal or sensitive nature. Differ from individual interview, sensing interview is used as one of group-oriented method. Sensing interview is conducted to collect information from groups by a series of questions to groups. This method that may be preferable to individual interview in terms of time saving group support of ideas. However, it need to be carefully design questions for sensing interview since all group members listen answers from each members. Regarding to observation methods, several types of method are systematic observation, complete observation, or participant observation. These methods range from observing behaviour of sample or individual to group. Observation methods help researchers to decrease the intervention impact during the data collection process. Data is more natural when people are not required to provide answer directly by interviewers. Systematic observation frequently requires a sampling of the individual behaviour. For example, interactions between certain people could be observed on a random basis. After a series of observations, a pattern would evolve, showing what problems typically were encountered. Complete observation is conducted by using a camera, audio recorder, or other such techniques to record group behaviour. For more explanation of these methods, please refer to Bouchard (1976) and Nadler (1977).

Methods to collect data on communication structures in TTX are proposed regarding two factors. For perspectives of researchers on communication structure in two domain of social process, TTX could be rule-based or behaviour-based event. The remaining factor is sources of information with involvements of individuals or groups. For an event, it might be activities of individuals or groups, but TTX is the event of groups to discussion together other individual activities. Table 4-1 shows our proposed methods for situations. Each method has unique features that influence its appropriateness.

Table 4-1: Proposed methods to collect data in TTX

	1. Rule-based event	**2. Behaviour-based event**
1. Individuals	1.1. Interview	1.2. Systematic observation
2. Groups (for TTX)	***2.1. Sensing interview***	***2.2. Complete observation***

4.2.2. Applied data collection methods in case studies

Through two case studies (TTX 1 and TTX 2) in Haiphong city, Vietnam, methods to collect data are applied “2.1. Sensing interview” and “2.2. Complete observation”. The TTX 1 was designed and analysed for stakeholders in environmental issues. Sensing interview was used as method to collect data in TTX 1, since the exercise was designed as rule-based event to identify relationship among stakeholders according communication rules and participant’s knowledge. Four officers from different organizations participated in TTX 1. The TTX 2 was developed for firefighting and rescue issue. TTX 2 was designed and conducted by cooperation with Firefighting Police Division of Haiphong city (FFPD). Complete observation was used to collect data for the exercise since the exercise was considered as a behaviour based event to observe communication structures of rescue teams for specific situation of rescue activities. Twelve participants in TTX 2 were divided into two rescue teams, and responding to two injects. In TTX 2, voice recorders were used to collect communication data in each team. Verbal records then were used as data sources to understand communication structures of two teams.

Table 4-2: Characteristics of two TTXs in Haiphong city

	Table-top exercise (TTX 1) *(Rule-based event)*	Table-top exercise (TTX 2) *(Behaviour-based event)*
Data collection methods	Sensing interview	Complete observation
Research Objectives	To identify relationship among stakeholders according communication rules and participant's knowledge	To identify communication structures for specific situation of rescue activities.
Participants (Discussion group)	- 1 officer from safety division of Haiphong port. - 1 officer from the Division of Sea and Islands, Haiphong Department of Natural Resources and Environment (Haiphong DONRE). - 2 officers from Centre for Environmental Monitoring, Haiphong Department of Natural Resources and Environment.	- 11 officers from different sections of Haiphong Firefighting Police Division (FFPD). - 1 leader of secure division of Haiphong International Hospital.

4.3. Case study 1: TTX 1 as rule-based event

4.3.1. Overview of TTX 1

From key issues in environmental emergency risk at port that were found in Chapter 3, TTX 1 was designed to focus on issues related to regulations, plans, organizational capacities and relationship among stakeholders when oil-spill incidents occurred at Haiphong port. I invited four officers from three different divisions in Haiphong city to join in the TTX as participants. They are 01 officer from safety division of Haiphong port, 01 officer from the Division of Sea and Islands, and 02 officers from Centre for Environmental Monitoring, Haiphong DONRE. If oil spill occurs at Haiphong port, safety division is in charge of responding oil-spill as the first level, while DONRE plays as the main state management agency for environmental accidents in Haiphong.

The exercise was intended to be a safe, open and stress-free environment for participants. An explanation of the purpose of the exercise was clear mentioned in exercise plan, that was distributed to participants before exercise. TTX 1 was conducted during two hours on April 26th, 2019. I firstly made self-introduction to participants and specified again the purpose of the exercise. After that, TTX 1 was driven by a series of questions from me as the facilitator to participants in turn as inputs. Outputs are answers and discussions from them. Key information of participant's answer were recorded.

4.3.2. Methods

Questioning technique

Designing questions is very important technique in sensing interview method since it helps to gather better information and learn more from interviewees. Giving suitable questions is at the heart of effective communications and information exchange. There are some common questioning techniques including open-ended, closed, probing, funnel,… questions. Since TTX 1 is organized to encourage knowledge sharing and discussion among participants, two effectively questioning techniques are open-ended questions and funnel questions. Open-ended questions encourage participants a little more thought and facilitate discussion among them other than yes or no answer. Funnel questions, as with a funnel, questions were designed by beginning broadly before narrowing to a specific point. These questioning techniques help us to gain maximum amount of information from participants as well as share some common knowledge's before moving individual knowledge.

Four main questions were designed to collect necessary data for achieving research objectives as shown in Figure 4-2. Open-ended and funnel questions were used as two questioning techniques for TTX. These questions were provided to participants one at a time starting with Question 1. The first and second questions were targeted to raise general points that all of stakeholders can share common knowledge, as one idea to bring them close to each other. Specific issues of responsibilities and cooperation were asked in Question 3 and 4.

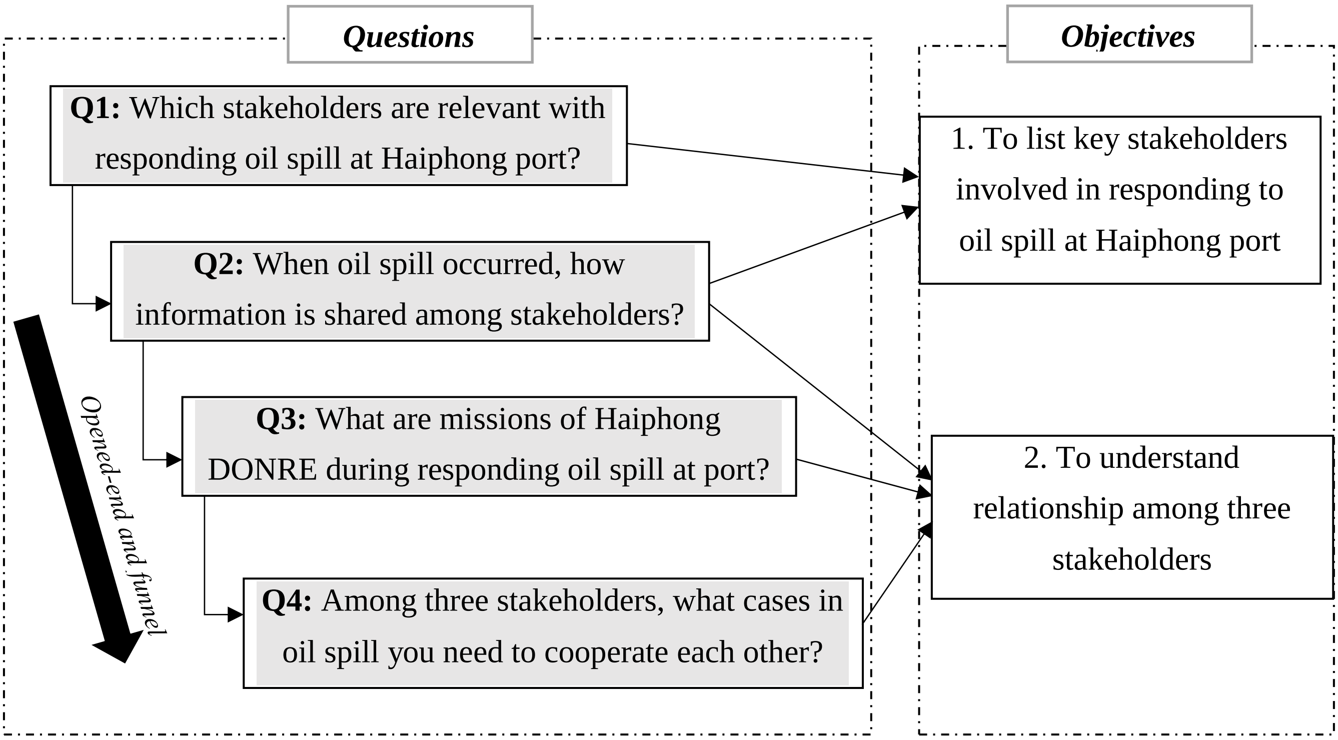


Figure 4-2. Questions and research objective of TTX 1

4.3.3. Results

4.3.3.1. Stakeholders involved in responding to oil spill at Haiphong port:

Stakeholders in oil spill response are depended on the seriousness of oil spill that classified to three tiers: small, medium, and large oil spills. A small oil spill is an oil spill in which the amount of oil being released is below 20 tonnes; a medium oil spill is from 20 to 500 tonnes; a large oil spill is over 500 tonnes. Three levels of deployed forces corresponding at levels of oil spill are in-house level, provincial level, and national level. List of stakeholders includes Commander and Responders is mentioned in Table 4-3. Through answers of participants, I defined information procedures among these stakeholders in Figure 4-3

Table 4-3: Commander and Responders at three levels

Levels of deployed forces	Highest level of Commander	Responders/Stakeholders
1. In-house level	- Director/Vice Director of Haiphong port (Hoang Dieu terminal)	- Safety division of Haiphong port - Haiphong Port oil spill response centre (belonged to Haiphong Port Tugboat and Transport Joint Stock Company)
2. Provincial level	- Chairperson/Vice Chairperson of the Haiphong People's Committees	- all of above forces and: - Standing office of Haiphong committee for natural disaster prevention and control and search and rescue (CNDPC&SR) - Haiphong Department of Natural Resources and Environment (DONRE) - Haiphong Firefighting Police Division (FFPD) - District-level of medical and police forces - Port Authority - Border guard - The National Northern Oil Spill Response Center (NANOS)
3. National level	- The National Committee for Incident and Disaster Response and Search and Rescue	- all of above forces and: - Ministry of Industry and Trade, - Ministry of National Defense - Ministry of Natural Resources and Environment

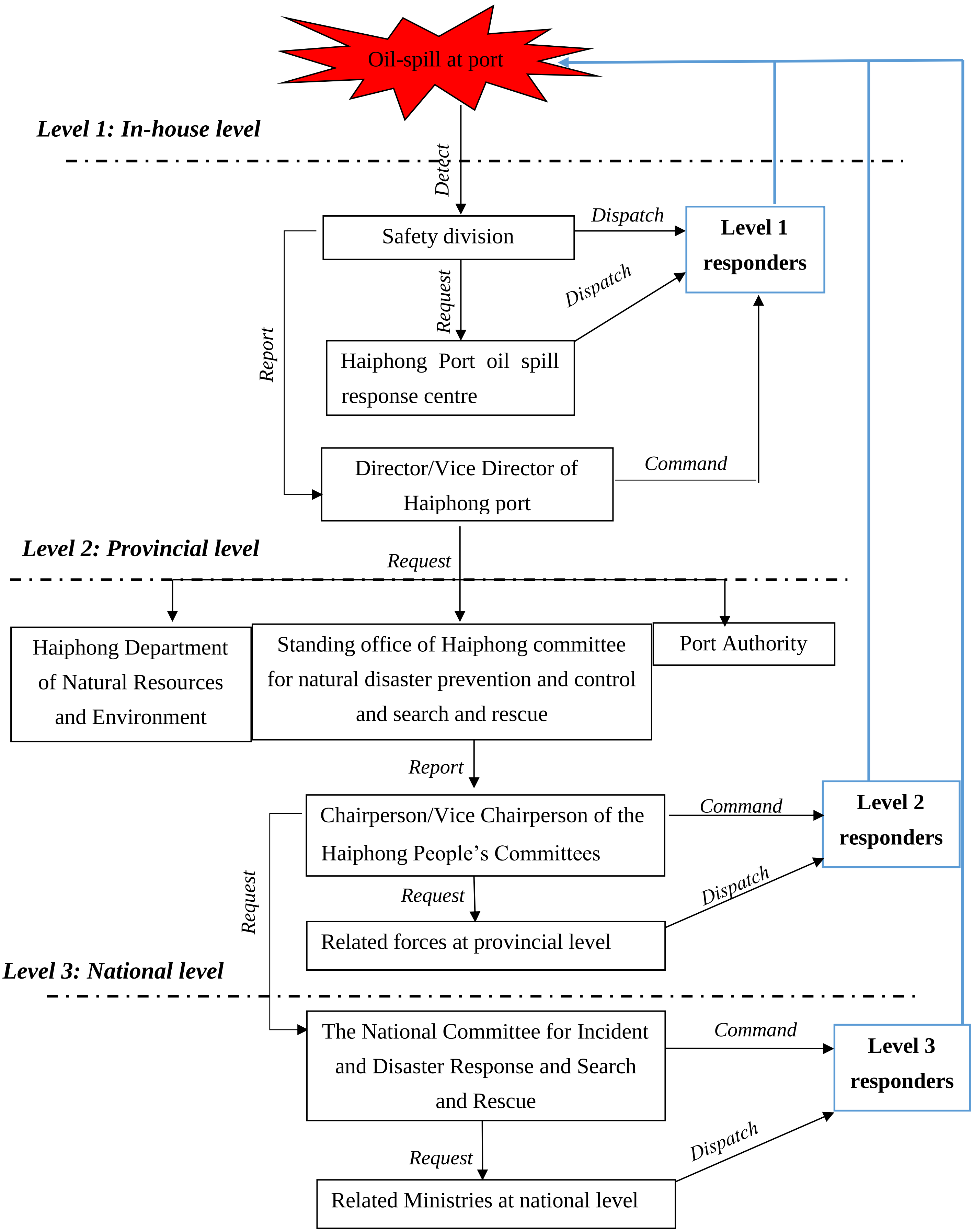


Figure 4-3. Information procedures among stakeholders

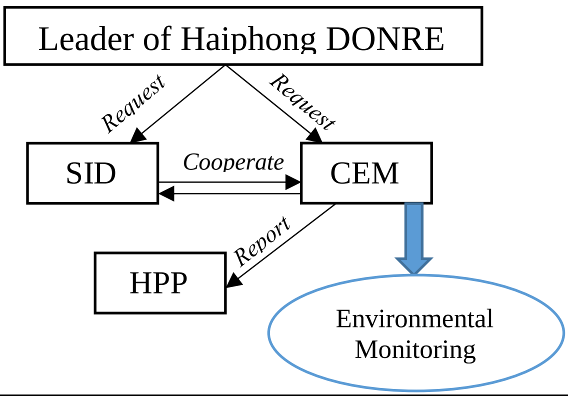
4.3.3.2. Relationship among three stakeholders

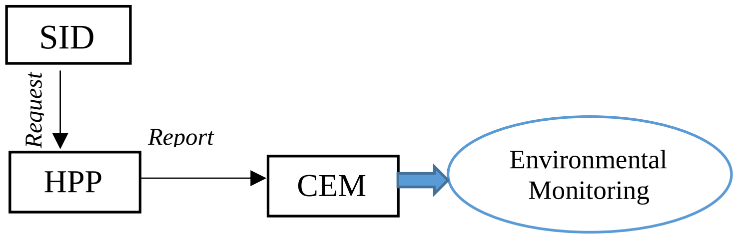
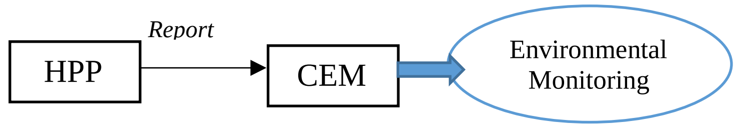
Participants in TTX 1 are from Haiphong port and two divisions of Haiphong DONRE. The Sea and Islands division is in charge of manging oil spill issues, while the Center for Environmental Monitoring is in charge of monitoring and measuring environmental quality. Question 3 was provide to understand about missions of two divisions of Haiphong DONRE during responding oil spill at port. Answers from participants from Haiphong DONRE show interesting information that they mainly involve in preparedness and recovery phase for oil spill other than response phase. In preparedness phase, Haiphong DONRE plays as the local governmental department to manage environmental issues, checking compliance of Haiphong port with laws. In recovery phase, DONRE is in charge of oil spill assessment and restoration. In oil spill response phase, leader of Haiphong DONRE is a member of committee for natural disaster prevention and control and search and rescue who is under command of city's leader to respond together with other forces. However, Haiphong DONRE does not have specific forces to respond oil spill. Their missions are to provide support to other forces if necessary.

Question 4 was provided to ask details of what cases in oil spill that two divisions of Haiphong DONRE and Haiphong port need to cooperate each other. They mentioned the mission to do environmental assessment and restoration after oil spill. Surface water quality around port area is important environmental element under high concern since it is related to assess ecological and aquaculture damages. They provided three cases that connect tasks among three stakeholders.

Table 4-4: Cases and communication links

HPP: Haiphong Port, the Sea and Islands Division: SID, the Center for Environmental Monitoring: CEM

Case	Content	Communication links
1	Leader of Haiphong DONRE requests subordinate divisions to conduct environmental assessment at port areas.	

Case	Content	Communication links
2	The Sea and Islands Division request Haiphong port to update information about environmental situation at port	
3	Haiphong port want to have data on environmental situation after oil spill	

4.4. Case study 2: TTX 2 as behaviour-based event

4.4.1. Overview of TTX 2

TTX 2 was conducted on December 13th, 2018 by cooperating with Haiphong FFPD. During two and half-hours, the exercises focused on rescue activities for a scenario on fire accidents in the Haiphong International Hospital. The beginning scenario was as follows: "At 9:30 of date X, a fire accident happens at the 6th and 7th floors of the Haiphong International Hospital. In that 19-story building, the fire expanded rapidly with toxic gases. Local firefighting forces cannot respond effectively to these problems. Many victims were trapped in the 6th and 7th floors in life-threatening conditions." Participants in the TTX 2 included a facilitator and players. There was also an audience. Among them, players were the main actors discussing and answering questions to explain how they respond to injects that sent from the facilitator. Two simulated rescue teams (Rescue team 1 and 2) included six members each, and these were the TTX players. Members from each team were selected by exercise facilitators two weeks before the TTX under priority to create good opportunity to discuss and share knowledge among the different sections of the FFPD. Team members included a vice leader of firefighting and rescue, leaders of local fire stations, captains of sections, and one manager from the Haiphong International Hospital. They were experienced firefighters and managers and were expected to provide realistic answers based on their experience of actual field responses. Table 4-5 shows the job titles of the players.

Table 4-5. Job title of members in Rescue teams 1 and 2

Number of Player	Rescue Team 1	Rescue team 2
1	Vice leader of firefighting and rescue (*)	Leader of local fire station area 2 (*)
2	Staff of the advisory section	Leader of local fire station area 4
3	Leader of local fire station area 1	Leader of local fire station area 5
4	Vice-captain of the logistics section	Staff of the firefighting and rescue section
5	Captain of firefighting and rescue on river	Captain of firefighting and prevention
6	Leader of secure division of the hospital	Staff of the logistics section

(*) Leader of Rescue team in TTX.

There were differences between individual players in the two simulated teams. Rescue team 1 included five members from the FFPD and one member from the hospital, whereas all six members of Rescue team 2 belonged to the FFPD. Moreover, the leader of Rescue team 1 has a higher job position for rescue tasks in the organization structure of the FFPD than the others. Meanwhile, the leader and some other members in Rescue team 2 had the same command and control rank in daily missions. In cases involving small fires, the leaders of local fire stations are assigned as the leaders of field teams. When accidents expand, a leader or vice leader of firefighting and rescue teams become commanders of local fire stations.

Both teams received an exercise inject simultaneously from the facilitator. Inject 1 of TTX simulated a situation where “Fire occurs from the hemodialysis room of the 6^{th} floor. The fire quickly spreads to the 7^{th} floor. It is noticed that some victims are trapped on these floors. As leaders and members in the rescue team, how do you conduct your tasks?” Each team discussed their responses and presented their results to the audience. The teams were provided with maps of each floor in the hospital to facilitate discussions. After answers to Inject 1, both teams took a break for five minutes before the facilitator provided Inject 2. This required teams to respond to another explosion on the 11^{th} floor in the same building. Inject 2 was as follows: “While responding to the fire at the 6^{th} and 7^{th} floor, another explosion occurs in the kitchen on the 11th floor. Some victims are calling for help. How do you respond to this situation?” Each team then discussed their responses and presented their results.

For TTX 2, complete observation was applied as data-collection method. Presentations. I recorded how each team respond to each inject by voice recording. For Inject 1, Rescue team 1 presented their response procedure for 13 minutes while Rescue team 2 used 12 minutes for theirs. For Inject 2, two verbal records of seven minutes for

Rescue team 1 and five minutes for Rescue team 2 were collected. After TTX 2, all members of both teams were asked to fill in a questionnaire. The questions used are explained in a section related to the player's attitudes on cooperation. All 12 members of the two teams answered the questionnaire.

4.4.2. Methods

4.4.2.1. Verbal protocol analysis

Verbal protocol analysis is a qualitative, process-tracing technique exploring information on the process of responders by recording verbal data (Ericsson & Simon, 1993). In the TTX, two rescue teams provided their answers about how to respond to situations in each inject. Their answers were informative, but it is difficult to see how they communicate with each other. Therefore, we applied qualitative coding techniques to extract the necessary information. This data technique is also recommended by qualitative methodological literature (Eisenhardt, 1989; Miles & Huberman, 1984). Since we are investigating the communication structures of rescue teams, we sorted information related to communication tasks and the actors in the tasks. In particular, we employed the technique of verbal protocol analysis as follows.

First, voice-recording files of each rescue team were transcribed to verbal reports. By reviewing each report, actors were defined including individuals, units belonged to the rescue team, and other stakeholders mentioned in verbal reports. The differences of actors in verbal reports between two rescue teams are shown in Table 4-6.

Table 4-6: Defining actors in verbal protocol data for teams 1 and 2

Actor	Mentioned by Rescue team 1	Mentioned by Rescue team 2	Main roles
Leader of Rescue team[1]	Yes	Yes	Commanding units to perform rescue function on site
Scout unit 1a[1]	Yes	No	Gathering information at 6th floor for Rescue team 1
Scout unit 1b[1]	Yes	No	Gathering information at 7th floor for Rescue team 1
Scout unit 2[1]	No	Yes	Gathering information at the 6th and 7th floors for Rescue team 2
Inside building unit[1]	No	Yes	Performing rescue activities inside buildings for Rescue team 2
Ladder unit[1]	Yes	Yes	Rescuing victims by using aerial ladders
Logistics unit[1]	Yes	Yes	Providing facilities and pre-medical supports for victims

Board of Field Commanders	Yes	Yes	Commanding all activities of firefighting and rescue on site
Local hospital team	Yes	Yes	Performing rescue activities together with rescue teams. This team is established by Haiphong International Hospital
Medical team	Yes	Yes	Supporting health care and operating ambulances. Members of this team are gathered from nearby hospitals

1. These actors belonged to rescue teams.

Second, actions related to communication tasks were extracted. To specify communication tasks, we used a well-known method of task analysis called hierarchical task analysis (HTA), which was introduced by Annett and Duncan (1967). The development of HTA from individual processes expands to teamwork by providing two-team process categories including "communication" and "coordination." In the communication category, three observable actions were "Send information," "Receive information," and "Discuss" (John Annett, Cunningham, & Mathias-Jones, 2000). Consequently, we expected actions that related to communication tasks among actors as follows:

- Inquiry: when an actor collects or receives information from other actors to conduct subsequent tasks.
- Request: an action whereby an actor sends information to other actors requesting specific actions toward attaining goals.
- Report: when an actor sends information to other actors to share information and understanding.
- Cooperate: when actors work jointly towards the same goal. That action requires two-way communications between two actors.

Third, single communication links were created by combined information related to actors and communication tasks. According to Adler and Towne (Adler & Towne, 1978), communication is a process between two or more actors defined as sender and receiver. A single communication link can be described by arranging a chain as follow: "Actor 1—Communication task—Actor 2." Meanwhile, the direction of information flow can be determined by reviewing the characteristics of communication tasks. In particular, "inquiry" implies information from Actor 2 to Actor 1, while "request" and "report" means that Actor 1 sends information to Actor 2. Since there is no direct information flow in "cooperation," this study assumed that both information flows existed in this type of communication task. By extracting verbal protocol data of two rescue teams, we could define 36 and 35 single communication links of Rescue team 1 and Rescue team 2 respectively. These communication links were data sources for social network analysis.

4.4.2.2. Social network analysis

SNA was used to identify the characteristics of the communication structure of two rescue teams. An important benefit of using SNA is to investigate patterns of relationships among actors (Wasserman & Faust, 1994). Some researchers of emergency responses have applied SNA to evaluate organizational relationships in the existing literature. For example, SNA techniques were employed to define key actors of multi-organizational coordination structures of emergency responders of the West Java earthquake in Indonesia (Bisri, 2013). Relationships among organizations and their emergency operations in catastrophic disasters were assessed using SNA (Kapucu, Augustin, & Garayev, 2009). Moreover, SNA also provides a mathematical approach to study the characteristics of connections among actors (Magsino, 2009).

Input data of SNA consists of information related to actors, links among actors, and the characteristics of actors. SNA can illustrate communication structures among actors by visualizing networks in sociograms (Wasserman & Faust, 1994). Sociograms show nodes representing actors, for example, units of a rescue team, the links among actors by lines, and arrows of lines representing information flow. After the communication links of both Rescue teams were defined, we created matrices to show the relationships among the actors of each team. Both internal and external communications during the operation of rescue teams were considered. Then, sociograms for each rescue team were drawn by using UCINET software to understand the general communication structures of each team. Subsequently, some useful metrics of SNA which could help identify the characteristics of communication structures were selected by understanding their application in some existing studies (Furht, 2010; Magsino, 2009; Park, 2011). Our paper focused on following metrics to highlight cooperation among actors of each team from the communication structures.

1. Degree of communication: the number of links from one actor to other actors in the network (Kosorukoff, 2011). If links between actors have direction, two separate measures of degree are defined, namely in-degree and out-degree. The in-degree of

an actor u is the number of links received by u and the out-degree is the number of links initiated by u ("How to Use - UCINET Software," n.d.).

2. Network density: is a measurement indicating the ratio of the actual ties or lines connected among actors to the maximum possible number of lines among actors that the network could have (Borgatti & Everett, 2006). The higher the density value, the more likely that actors are connected to each other. The number of possible connected lines in a network with g actors is g*(g-1)/2. Our calculation for network density ignored the direction of lines between two actors. Network density is measured using Equation 1:

$$\Delta = \frac{2L}{g(g-1)} \tag{1}$$

Where Δ is the network density, L is the total number of existing lines in the network, and g is the total number of actors;

3. Network centralization: Network centralization indicates which network is more organized around its most central point (Freeman, 1977). The network centralization mirrors how relationships are distributed through the network. A highly centralized network means that a smaller percentage of actors have a higher percentage of relationships with other actors in the network. Conversely, a low centralized network means that most actors in the network have an equally distributed number of relationships. Network centralization for one network can range from 0 (decentralization) to 1 (centralization). 0 indicates a completely decentralized network. To determine the network centralization, these steps should be conducted:
   - Calculating the degree of centrality C_i (i from 1 to g) for each actor in the network. The degree of centrality is different from the degree of communications. The degree of centrality of an actor is the number of lines between the actor and other actors. If the network includes g actors, the maximum value of C_i is g-1.
   - Defining an actor* who has the highest value of the degree of centrality C*. An actor * is the most central actor.
   - Calculating differences between value C* and each of the others C_i.
   - Summing up the difference $\sum_{i=1}^{g}(C^* - C_i)$.
   - As the denominator of Equation 2, we calculate the maximum possible value of the sum of difference. The maximum degree of centrality for one

actor is g-1. Then the maximum difference for the remaining g-1 actors is g-1-1. The maximum sum of difference ignoring directions of communication flows then becomes (g-1)*(g-1-1) = (g-1)*(g-2).

- The network centralization can be calculated by using Equation 2. This equation refers to the equation in Freeman (Freeman, 1977)

$$Network\ Centralization = \frac{\sum_{i=1}^{g}(C^* - C_i)}{(g-1)(g-2)} \tag{2}$$

4.4.3. Results

4.4.3.1. Actors' matrices and sociograms of two rescue teams

As expected from the lack of a standard organizational structure, the two teams of TTX provided different answers to the exercises. First, the matrices of actors in each team were created to recognize the features of relationships among actors. The social networks of teams were then visualized by using sociograms. Table 4-7 and 4-8 show matrices of actor relationships for Rescue teams 1 and 2, respectively. Figure 4-4 and 4-5 illustrate the sociograms of each rescue team.

Table 4-7: Matric of actor relationships for Rescue team 1

From \ To	Board of Field Commanders	Ladder unit	Leader of Rescue team	Local hospital team	Logistics unit	Scout unit 1a	Scout unit 1b	Medical team
Board of Field Commanders	0	0	3	0	0	0	0	0
Ladder unit	0	0	0	0	0	0	0	0
Leader of Rescue team	5	4	0	4	2	2	2	0
Local hospital team	0	0	3	0	0	1	1	0
Logistics unit	0	0	1	0	0	0	0	2
Scout unit 1a	0	0	1	1	0	0	0	0
Scout unit 1b	0	0	1	1	0	0	0	0
Medical team	0	0	0	0	2	0	0	0

Table 4-8: Matric of actor relationships for Rescue team 2

From \ To	Board of Field Commanders	Inside building unit	Ladder unit	Leader of Rescue team	Local hospital team	Logistics unit	Medical team	Scout unit 2
Board of Field Commanders	0	0	0	2	0	0	0	0
Inside building unit	0	0	2	0	1	1	0	3
Ladder unit	0	2	0	0	0	1	0	2
Leader of Rescue team	1	3	0	0	0	0	0	3
Local hospital team	0	1	0	2	0	0	0	0

Logistics unit	0	1	1	0	0	0	1	0
Medical team	0	0	0	0	0	1	0	0
Scout unit 2	0	3	2	2	0	0	0	0

The leaders of the rescue teams and four units with specific functions were considered as actors belonging to the rescue teams. Meanwhile, the Board of Field Commanders, Local hospital team, and Medical team were stakeholders mentioned by members of two rescue teams in TTX. It is interesting that the leaders of two rescue teams made different decisions on establishing subordinate units. Scout units 1a and 1b in Rescue team 1 were assigned the same type of missions, but each unit was in charge of responding on two different floors. Conversely, the leader of Rescue team 2 directed Scout unit 2 and the Inside building unit two do different missions. Scout unit 2 was directed to first go to disaster sites on both floors in the hospital to collect information, whereas the Inside building unit was in charge of rescuing victims. Both leaders of the rescue teams established the Ladder unit and the Logistics unit.

In sociograms, we draw actor's shapes according to whether they belonged to rescue teams in square shapes or belonged to other teams in circle shapes. The weight of lines between actors illustrates the differences in the number of communication links. Thicker lines indicate more communication links or the degree of communication between two actors compared to others. First, we reviewed the communication structure among actors who belonged to FFPD including the Board of Field Commanders, leaders of the rescue teams, and the subordinate units. Communication links existed between the Board of Field Commanders and the leaders of the rescue teams in both sociograms. However, relationships among the leaders of the rescue teams and the subordinate units differed. In Rescue team 1, the subordinate units communicated with the leader who became the center point of communication networks. Meanwhile, communication links between the leader of the team and Ladder unit and Logistics unit were not recorded in Rescue team 2. Instead, direct communication among the subordinate units was used. Regarding networks with external actors, the sociograms show that members in Rescue team 1 had more communication links with the Local hospital team than the network of Rescue team 2. I will investigate the characteristics of communication structures of the two rescue teams in detail using key metrics of SNA.

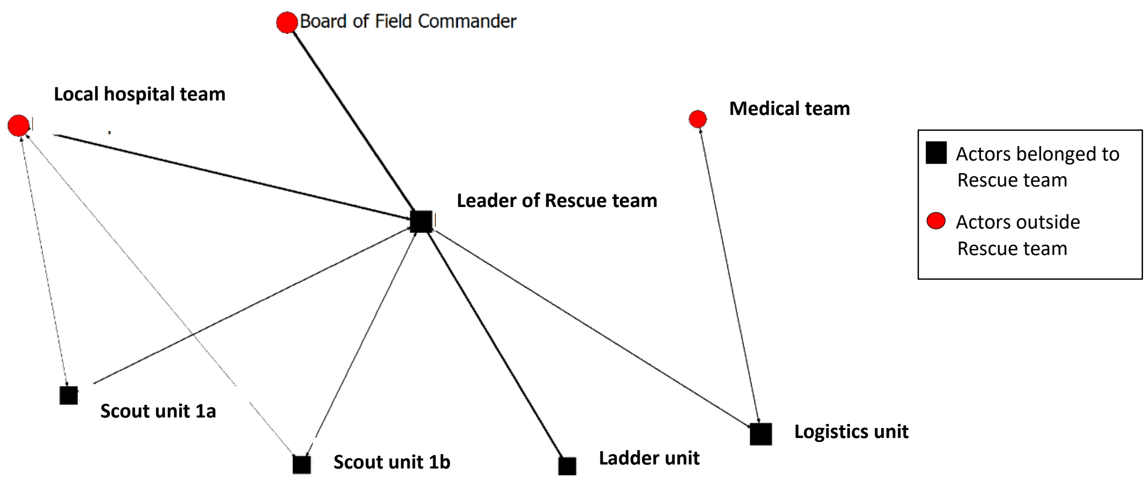


Figure 4-4. Sociogram of Rescue team 1

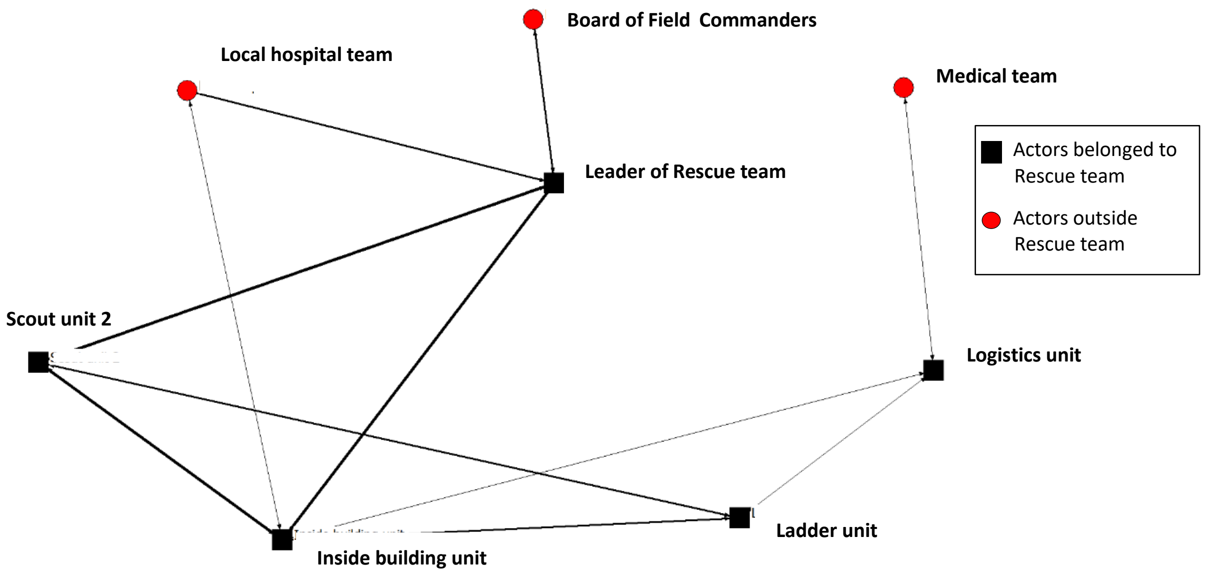


Figure 4-5. Sociogram of Rescue team 2

4.4.3.2. Metrics of social network analysis

a, Degree of communication

The degree of communication for each actor is the number of links between that actor and other actors in the network. Since the direction of information flows was considered in this metric, both the out-degree and in-degree of communication were counted. The out-degree of an actor is the number of links initiated by that actor, while the in-degree is the number of links received by the actor. Table 4-9 shows the results of the communication degree of actors in the network of Recuse team 1 and 2.

Table 4-9: Communication degree of actors in the networks of Rescue teams

Actors in the network of Rescue team 1	Out-degree	In-degree	Actors in the network of Rescue team 2	Out-degree	In-degree
Leader of Rescue team	19	9	Leader of Rescue team	7	6
Scout unit 1a	2	3	Scout unit 2	7	8
Scout unit 1b	2	3	Inside Building unit	7	10
Ladder unit	0	4	Ladder unit	5	5
Logistics unit	3	4	Logistics unit	3	3
Board of Field Commanders	3	5	Board of Field Commanders	2	1
Local hospital team	5	6	Local hospital team	3	1
Medical team	2	2	Medical team	1	1
Total links	***36***	***36***	***Total links***	***35***	***35***

The total communication links in each rescue team were quite similar. There were 36 links for Rescue team 1 and 35 for Rescue team 2 and the degree of communication for each actor greatly differed between the two teams. I highlight two issues in comparing the degree of communication among actors. First, the degree of communication of the leader of Rescue team 1 was the highest in the network. This explains the vital role of the leader in maintaining communications for Rescue team 1. By reviewing the communication tasks of the leader of Rescue team 1, we found that 15 of 19 out-degree links of the leader requested units and other stakeholders to do specific tasks. Conversely, the numbers of in-degree and out-degree links of the leader of Rescue team 2 barely differed compared to the units in Rescue team 2. Communication links among units were found in this team that differed for the network in Rescue team 1. Second, the intercommunication between members of rescue teams and other stakeholders were reviewed. Rescue team 1 mentioned more communications with other stakeholders than Rescue team 2. This argument was revealed by observing higher numbers of communication degrees of the Board of Field Commanders, Local hospital team, and the Medical team for the network of Rescue team 1. Especially, more links between the Local hospital team and Rescue team 1 in the communication network were recorded. The difference in communication structure between the two teams might be related to the job position of the team leaders and relationships among team members. In Rescue team 1, the leader had the highest job position in the actual structure of FFPD, and they became the hub of the communication structure to receive and dispatch information. Moreover, one person from the Haiphong International hospital joined in Rescue team 1 for discussions in TTX while all members of Rescue team 2 belonged to the FFPD. It is observed that the degree of communication of the local hospital team in team 1 was higher than in team 2.

b, Network density and centralization

The characteristics of the communication structure in each rescue team were explained by measuring the network density and centralization. The higher the density value, the more likely that actors in the network were connected to each other. Meanwhile, network centralization measures the centralization level of networks. Table 4-10 compares key results by calculating the network density and centralization of Rescue team 1 and 2.

Table 4-10: Key results by calculating network density and centralization

	Rescue team 1	**Rescue team 2**
Number of actors (g)	8	8
Total number of links in the network (L)	9	11
Network density (Δ)	0.321	0.393
Highest value of degree centrality C*	7	5
Name of Actor *	Leader of Rescue team	Inside building unit
Network centralization	0.881	0.428

The result shows that the values of network density for two rescue teams barely differed. Approximately 32.1% and 39.3% of the possible connections in the network of Rescue team 1 and 2 respectively had been made. Meanwhile, the values of network centralization show substantially different centralization levels between the two teams. The network centralization of Rescue team 1 is relatively high at 0.881. The key actor in this network is the leader of Rescue team 1 who also had the highest communication degree. This result is supported by reviewing the sociogram of Rescue team 1 which shows the leader is the center of the network. Conversely, the network centralization for Rescue team 2 is 0.428. This explains that information among actors was more openly shared in the network of Rescue team 2. Direct communication among the units of Rescue team 2 was found in the network.

Another interesting finding of this analysis is that, despite the differences in sociograms and levels of network centralization between the two teams, the network density was almost identical across those teams. This is a non-obvious insight that SNA revealed. The reason for this similarity needs further research. SNA technique helped us to identify key features of detailed communication structures to focus on.

4.4.3.3. A comparison of attitudes on cooperation inside and outside rescue teams

The findings from SNA revealed two different communication trends of two rescue teams. The members in Rescue team 2 were more interested in communicating among units inside the team but mentioned their communications with other stakeholders less. In comparison to Rescue team 2, the leader of Rescue team 1 was a key actor communicating with units inside the team while there was a lack of direct links among units in the network. However, more communication links between Rescue team 1 and other stakeholders were recorded.

To better understand attitudes on the cooperation of the members in each rescue team, we conducted a questionnaire survey for team members after TTX. One section of the survey concerned members' attitudes on cooperation inside the team and with outside stakeholders. Four issues of cooperation were raised to investigate the attitude of members. They were asked to choose one of four options from level 1 (not necessary at all) to level 4 (very necessary) on each issue. Figure 4-6 shows the results of the survey for the two rescue teams.

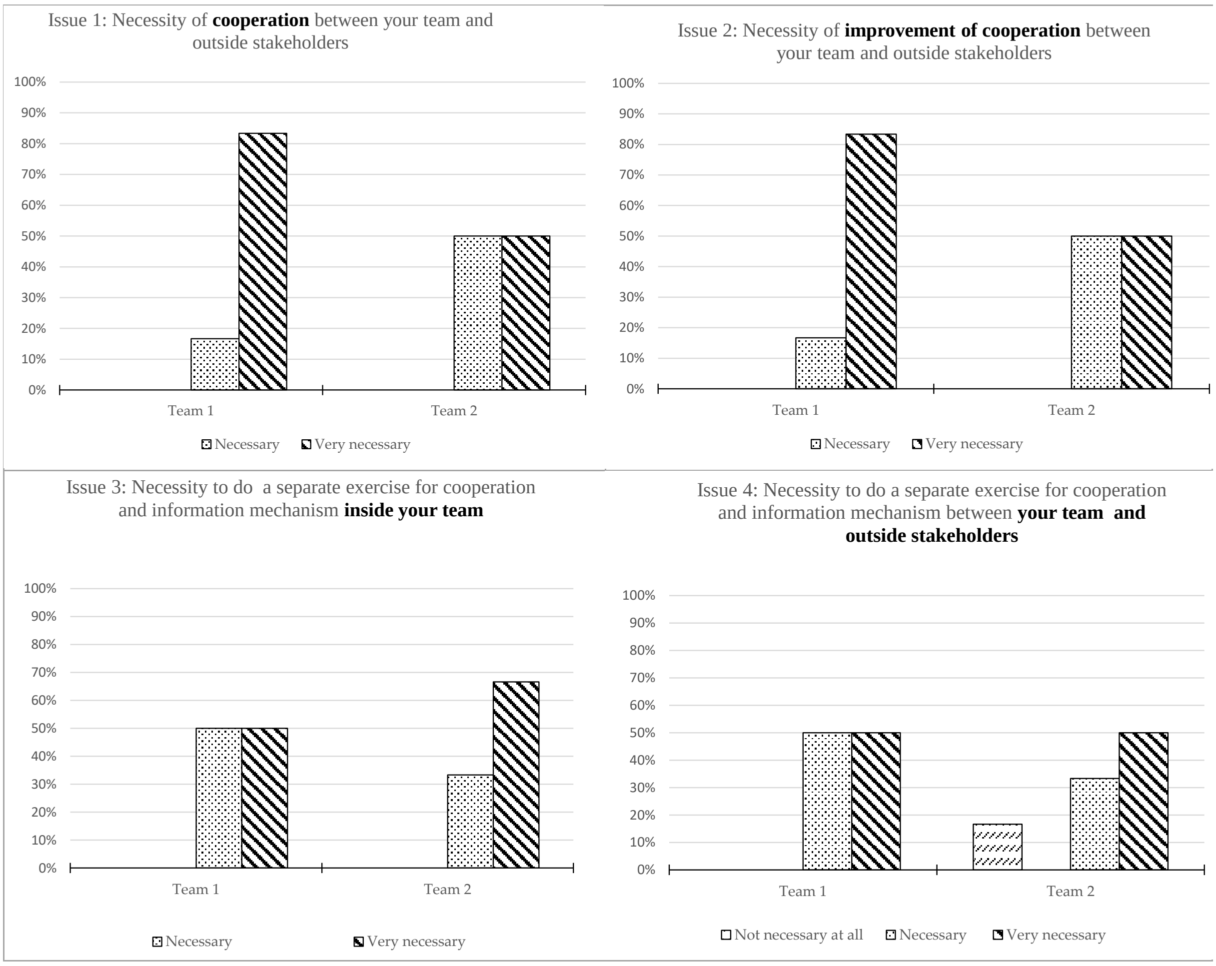


Figure 4-6. Survey of team's attitudes on cooperation inside and outside rescue teams

Both results of issue 1 and issue 2 show that members of Rescue team 1 had more concerns in cooperating with other stakeholders than Rescue team 2. More than 80% of members in Rescue team 1 think that cooperation as well improvement of cooperation with outside stakeholders are very necessary. Issue 3 and issue 4 were provided to collect their opinions whether if it is necessary doing a separate exercise to improve cooperation. Regarding issue 3, members of Rescue team 2 show their interest in using an exercise to improve cooperation inside the team. Results from the questionnaire survey reflect the trend of communication structures from social network analysis for two rescue teams.

4.5. Summary of Chapter 4

4.5.1. Conclusion

In this chapter, we have proposed methods to collect and extract data from TTX according to two different types of event. The TTX can be a rule-based event or behaviour-based event that might be applied sensing interview or complete observation respectively for collecting data from TTX. Data that facilitates exercise participants to better understand relationship and communication structures among organizations is focused. Through two case studies (TTX 1 and TTX 2) on emergency issues, we tested methods and applied techniques that finally achieved research objectives of each case. This chapter contribute to enhance benefits of TTX that helps stakeholders clearly identifying their relationship with partners. Although we used two case studies in Vietnam, this systematic approach to identify communication structures of emergency responders can be applied for different emergency issues in other nations.

Case study 1 was designed as a rule-based event for groups to identify relationship among stakeholders of environmental issues. Sensing interview method and questioning technique were applied to collect data from TTX 1. Through answers from four participants from three different organizations, we have listed key stakeholders involved in responding to oil spill at Haiphong port. Information procedures among stakeholders at three levels of responders have visualized. Specific roles and communication links among three stakeholders have been defined. These detail information on communication structures are difficult to collect without interviewing or observing participants. Legal documents from government normally provide general information about roles of organizations that make them easier to adapt for different contexts. From conducting TTX, and extracting data, I was able to provide more details information and visualize relationship among stakeholders in oil spill accident at Haiphong port.

Case study 2 was designed to investigate the communication structures of two rescue teams in a fire accident at hospital. Communication structures between two rescue teams have been compared for same exercise injects. Since there is room for discretion in a team leader to communicate with and organize units of field teams, such detail information is difficult to obtain by reviewing legal documents or interview. Complete observation was used to collect data in this TTX. Verbal protocol analysis and social network analysis were two main techniques to extract and analyse data from TTX 2. Based on a systematic research approach of this case study, we demonstrated that SNA is useful to identify the characteristics of the detailed communication structure of field response teams. Sociograms helped us to visualize communication networks among actors of each team, while metrics of SNA provided quantitative results regarding the characteristic of communication structures. The results from SNA were also compared with results from the questionnaire survey after TTX 2.

For more detail results of case study 2, SNA revealed that there were different characteristics of communication structures between Rescue team 1 and 2. More communication links between Rescue team 1 and other stakeholders were observed while Rescue team 2 were interested in practicing communication among units inside the team. The leader of Rescue team 1 was the center point of information flows which made the centralization level of Rescue team 1 much higher than team 2. Results of a questionnaire survey for team members on cooperation within the team and with outside stakeholders were relevant with analyzed results by SNA.

4.5.2. Further issues

Since TTX is targeted to provide a stress-free discussion environment for participants without actual operations, it is important to observe a TTX to discover key supporting information to then share and discuss among stakeholders as good evaluation program. I focused to proposal methods and techniques to collect and interpret data on communication structures among stakeholders through TTX. Information related to communication structures include communication actors and links, types of communication task that can be used for designing functional exercise (FX). To make database for designing FX, a series of TTX can be conducted to obtain key information.

It is also necessary for participants from different organizations getting acquaintance in TTX before among participants before advancing to FX.

5. USE OF A TIME ELEMENT FOR FUNCTIONAL EXERCISE

5.1. Introduction

Along with history, human being has had to face with various types of emergencies (Canton, 2007). These events affect to organizations and communities that generated from nature and in the process of society development. Disaster management and also called as emergency management is defined as the profession to address the management of disasters (Haddow, Bullock, & Coppola, 2014) that includes activities to prepare before, respond during, and recover from disasters. In the context of climate change, deforestation and industrialization, emergency events are becoming more complex (Few, 2007). Therefore, there is high demand to enhance capacity of organizations against higher risk of disasters, as well as cooperation among stakeholders including governmental, social and private organizations to overcome difficulties.

Emergency preparedness exercise is conducted for enhancing the capability of organizations for responding to disaster. It is also noticed that exercise is a key component of a good management program of International Atomic Energy Agency (2005). Five main types of emergency exercise are orientation, table-top exercise, drill, functional exercise and full-scale exercise. Emergency exercise is divided into two categories named discussion-based exercise and operations-based exercise. First category is discussion-based exercise that includes Seminars, Workshops, Table-top and Games. These exercises provide environment for sharing policy, discussing and developing plans, response procedures. The main key successful points of these exercises are to create understanding and improving knowledge of participants. The most common discussion-based exercise is the table top exercise (Canton, 2007). Second category is operations-based exercise that provides highly stressful environment for participants to practice on tactical and operational tasks. Response capacity of an organization could be measured through operations-based exercises. There are three levels of operations-based exercises including Drills, Functional exercises, Full-scale exercises. Drills normally focus on specific function or operation to train field responders and check utility of equipment. On the other hand, functional exercises (FX) test multiple functions that focus on co-ordination issues and decision making network. Common goals of functional exercise are to assess the adequacy of response plans, evaluate management capability of emergency operations division, or headquarters through providing various events continuously. Full-scale of exercise is most complex type of exercise involving different functions in real-time and actual deployment of resources in a coordinated response. As building block approach, successive exercises should be built on experience and lesson learnt from the previous one to ensure progression in exercise design (Figure 5-1).

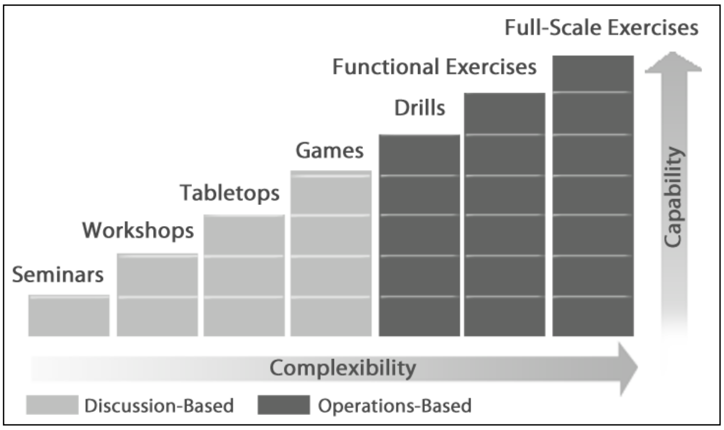


Figure 5-1: Building block approach

Among these exercise types, functional exercises are most suitable for improving communications, clarifying roles and responsibilities, and identifying opportunities for plan improvement. In a FX, a series of simulated emergency events, or “exercise injects,” are provided by exercise controller to participants, or “players,” and they find solutions together to the problems specified in those injects. There are a number of injects delivered in a functional exercise that make the event look real. Players order a resource but do not actually deploy them unlike drills. Evaluators are necessary in this type of exercise to observe and evaluate player operation.

Methods and tools to evaluate functional exercises for better disaster preparedness are still under development. In FX, two main evaluation criteria are how well the exercise meet its objectives and how tasks are performed by players (Canton, 2007). In the first issue, it aims to evaluate quality of exercise implementation compared with initial exercise objectives that latter used to improve the design of future exercises. Collecting opinion of all participants by questionnaire or survey after exercise is common applied. In the second issue, performance in exercise of participants is observed. A number of tools for evaluating performance in exercise have been recently developed. Homeland Security Exercise and Evaluation Program (HSEEP) provides template of Exercise Evaluation Guide (EEG) as a consistent tool to evaluate trainee’s performances and rate their achievements into a target rating system (2013). Another evaluation instrument of the Harvard School of Public Health (HSPH) (2013) for health emergency preparedness exercise is a combination of action checklists, subjective scoring system, and subjective comment fields. Meanwhile, Savoia et al. (2014) defines common instrument to measure performance in exercise including checklist, score, open ended questions. She also points out the necessary to gather data in quantitative or standard ways rather than narrative in form in public health system exercise. Another researcher, Nelson et al. (2007) declared that there is lack of metrics involving time-based attributes to observe and evaluate exercise. Moreover, rapidity and efficiency with provided emergency medical services will be proportional to the number of lives saved (Alexander, 2002), time is an important factor that should be consider more seriously to evaluate performance in medical emergency exercise. Therefore, studies on time-factor to evaluate performance in FX are in high potential development.

There is lack of records in Vietnam about how FX is conducted. Although FX is important for enhancing communication among stakeholders, Vietnamese laws on emergency management do not request organizations to do functional exercise. Law on Natural Disaster Prevention and Control, Law on Fire Prevention and Fighting, and Law on Natural Resources and Environment of Sea and Islands mention drill as the main type of exercise and training for organizations in emergency cases. It is understandable because of complexibility of FX as Figure 5-1, FX require capability of organizations such as exercise designers, controller and evaluators. It is also difficult for all organizations conduct FX since there is lack of emergency experts. In recent years, some organization have conducted training programs to operate cooperation mechanism among several stakeholders, for example, "Prevention of terrorism at the Thong Nhat Hospital" (HCM City in 2015); "Operation mechanism of search and rescue for airplane" by Vietnam Flight Management Corporation (HoaBinh, RachGia in 2017). There are also similar exercises to operate the armed forces mechanism in training Defense forces. For the field of fire fighting and rescue, the current main exercise type is drill that includes a simple practicing cooperation mechanism in the beginning of exercise. For all of these exercises, lack of detail information on evaluation methods and exercise results. Subjective comments by leaders are normally in Vietnamese emergency exercise program.

In Kitakyushu city, a recent development of FX is called as Kitakyushu functional exercise (KFEX). KEFX is a new style of doing functional exercise that has been applied for city level exercise, and disaster medical operation center in Kitakyushu city, Japan. This advanced FX style provides chance to record task processing time of communication among players by clearly defining task processing network for each inject. Time data is quantitative metric to provide useful information for emergency manager to deeper analyse exercise as well as understand their organizations. There is under development of how to use time data for finding clues in FX.

In this chapter, we aimed at developing a method to analyze the time required to complete emergency management tasks in functional exercises to find clues to improve job performance of the emergency management organization. Before moving to case studies, we review importance of time in management, time study in work-related performance and functional exercises. I then propose methods, and techniques to analyze data collected from functional exercise. Both Japanese and Vietnamese case studies are considered in this chapter. In the next section, we provide literature review related to time issues in management. Section 3 is research methods, while Section 4, 5 and 6 explain three case studies. Section 7 draws some conclusions and future implications for developing evaluation methods of functional exercises.

5.2. Literature review

5.2.1. Importance of time in management

Temporal aspects are critical for understanding both human behavior and the activities of organizations (Navarro, Roe, & Artiles, 2015). In recent literatures of management and work and organizational psychology, time is defined as element of a construct (Roe, Claessens, & Rutte, 2008). Some authors studied constructs referring to subjective time such as time pressure (Syrek, Apostel, & Antoni, 2013), time demand (Castro, 2012), or time experience (Zimbardo & Boyd, 1999). Other researchers investigated constructs related to objective time such as time management, timing, time delay (Roe et al., 2008). Time management is one of specific area of the relevance of time for understanding human behavior in work and organization. Drucker (1967) introduced time management as method to increase work effectiveness and performance through managing time. Lakein (1984) considered various activities in time management from techniques to plan activities, make to-do-list. Claessens, W. Eerde, Rutte, & Roe (2007) defined time management is as "behaviors that aim at achieving an effective use of time while performing certain goal-directed activities." Time is considered as one of core metrics to evaluate process along with quality, productivity and cost (I. Kato & Smalley, 2010).

Depending on functional areas and type of organizations, time management plays different roles and applications. Time management in business world is well known with statement "Time is money." Managers and employees are interested in minimizing the consumption of time that seen as input source of production process of goods. Taylor (1911) defined in terms of efficiency in producing goods and maximum productivity. He mentioned both benefit for factory owners and workers through making shorter time consumption to create one unit of product. In production process, time passed or time used is a "cost". Framework of Toyota Production System (TPS) consider reduction of waiting time, lead-time, set-up time, as units to achieve cost reduction or improvement of productivities (Monden, 2012). Other areas of services, such as transportation, communication, logistics emphasize the requirement of timeliness, and "on time" to provide service to customers. In disaster or emergency management, response activities are required on time to meet the urgent needs of individual, organizations, and communities to reduce damages in disasters or incidents. In emergency medical service, delay in response time increases proportion of deaths (Gonzalez, Cummings, Phelan, Mulekar, & Rodning, 2009; Jaldell, Lebnak, & Amornpetchsathaporn, 2014).

5.2.2. Time study in work-related performance.

In work related processes, there are a variety of analysis techniques in industrial engineering and other fields. Four general types of analysis are described in Brannick, Levine, & Morgeson (2007) including time-and-motion study, functional job analysis, task inventory, and critical incident technique. Time-and-motion study are combined techniques of time study and motion study. In this section, we review motion study and time study since these studies include specialized techniques to improve efficiency of job performance. Meanwhile, time study is more focused because it considers time-factor in task performance's observation and evaluation.

Historically, motion study was first introduced in Frank Gilbreth's work in producing laying bricks from 1911 in an article in New York Times. Frank and Lilian Gilbreth developed 18 basic symbols called Therblig symbols to describe motion of workers (Ferguson, 2000). There are several techniques for motion study such as graphs and flowcharts, micro-motion analysis, and recording techniques. Idea of motion study is to breakdown job or task into smaller components that facilitate for reducing inefficient motion and providing some hints to improve processes. Motion method is mentioned in the book “Toyota Kaizen Methods with six steps to Improvement” of Kato and Smalley (2010) together with work-analysis study and time study. In chapter 5 of their book, work analysis study has five basic levels of the breakdown including job level, task level, major steps, work elements and motion detail. The most minute detail observation work is to consider motion of workers. The authors stressed the importance of choosing a proper level of observation granularity to find out problems in the targeted process.

Time study has improved from basic concept introduced by Taylor (1911). He discussed with factory employers to propose the use of performance standards for tasks in factories based on his study on processing time. In the basic level of time studies, job and work are breakdown into components parts, then measuring time consumption for filling in each part (Payne, Youngcourt, & Watrous, 2006). There are different techniques to conduct time study such as work sampling, direct (or stopwatch) time study, and predetermined time systems or industry standard data (Brannick et al., 2007). In TPS, completion time per unit of output is measured at each process and for each part that is used to construct standard operation routines. Both of the manual operation time and the machine automatic processing time are measured (Monden, 2012). This information and cycle time are basic component to create the standard operation routine that helps to reduce waiting time among sequencing processes. Time measurement and standard operations in TPS allows the supervisor optimizing operations of production lines. Result of time measurement is database to improve the standard operations regularly.

5.2.3. Evaluation methods in functional exercises in the United State

Even integrated approach of time study and motion study to improve task performance is applied to both industrial and service organizations (Ben-Gal, Wangenheim, & Shtub, 2010), there is limitation in application of time study to evaluate performance in functional exercises. Both template of EEG in HSEEP and evaluation instrument of the HSPH for health emergency preparedness exercise program do not have clear sections for measuring time of task performance. There were, however, some evaluation forms in existing functional exercises involving time-element. In particular, functional exercises of the Community Emergency Response Team (CERT) in guidance of Federal Emergency Management Agency in the United State apply observation form with recording time completed for each inject. Some exercise evaluation guidance manuals were published by California Department of Fish and Game (*Drills & Exercises and Evaluation Guidance Manual*, 2010) and International Atomic Energy Agency (2005) considering timeline in observation form for evaluators. In Columbia, the Public Health Emergency Exercise Toolkit (2006) for public health emergency exercise is developed that provides timesheet for recording “time in” and “time out” at stations in public health full-scale exercise. In general picture, common formats of observation tools in exercise include action checklists, subjective scoring system, and comment fields, and timeline. However, these observation tools in these functional exercises have not measured processing time for each communication-related task in functional exercises. A recent development of functional exercises is the use of IT technology to record communications among players. WebEOC, a product by Juvare, is known as one of such software used in Emergency Operation Center (EOC) to support for resources and task management. In Incident Notification Log for communication tasks via WebEOC, schedule of activities and time interval, communication partners and description of task are recorded, but time study and task-time analysis have not been integrated in modules of this software. Therefore, a serious consideration of time element to develop evaluation tools and analysis methods in emergency exercise can contribute further advancement in this field.

5.2.4. Evaluation program for Kitakyushu functional exercise (KFEX)

Kitakyushu Functional EXercise (KFEX) was firstly used to call the functional exercise of Kitakyushu city in 2007. The exercise simulated emergency response operation of organization in case of heavy rain and flood in Kitakyushu city. The exercise involved 476 participants from 12 different organizations (Kitakyushu Fire Department, 2008). In 2014, same type of functional exercise was also conducted in Kitakyushu city for responding and recovering from an earthquake. In the 2014 exercise, designers created 19 ESFs for emergency management in Kitakyushu city. Table 5.1 shows 19 ESFs of Kitakyushu functional exercise. From 19 ESFs, disaster narrative and major injects were provided. KFEX in 2014 involved 488 participants from organizations to practice in two sections including response and recovery with 503 injects (T. Kato et al., 2014).

Table 5-1: 19 ESFs in KFEX in 2014

ESF	Title	ESF	Title
1	Command and control	11	Public facility safety
2	Backup request	12	National relief law application
3	Volunteer coordination	13	Livelihood support
4	Communication	14	Health support
5	Evacuation warning	15	Body recovery
6	Shelter preparation	16	Epidemic prevention
7	Shelter operation	17	Garbage treatment
8	Logistics	18	Sanitation
9	Rescue	19	Water supply
10	Hospital reception		

One of important notice in KFEX style is that time element related to communication tasks was observed during exercise. To measure processing time of tasks, Kitakyushu Fire Department (2008) developed workflow to respond to each exercise inject by specifying relevant tasks, and the network structure of communications among emergency management groups. Then they measured the time required to complete each task and summarized the measured time to identify strength and weakness of the emergency management activities regarding each ESF. The concept of breakdown emergency job into tasks and time measurement in KFEX style is explained in Figure 5-2.

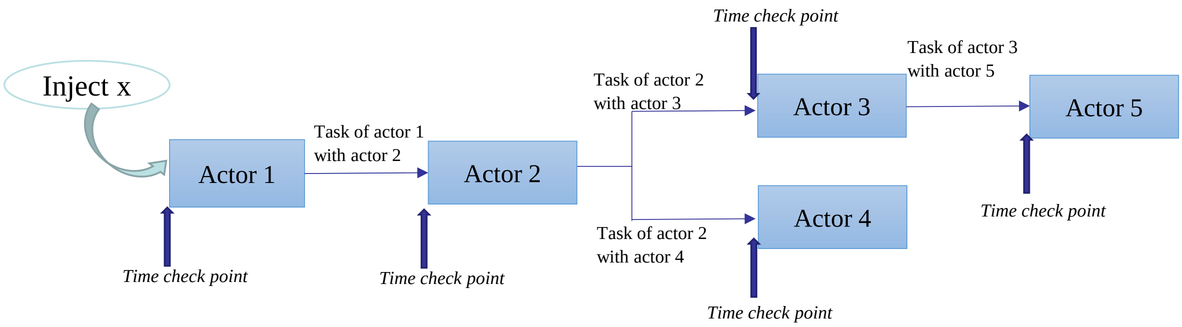


Figure 5-2: Workflow and time measurement in KFEX style

One of important difference between KFEX style and typical functional exercise is that workflow is defined for each inject in KFEX style. It means exercise planner need to define actors, tasks, time checkpoints for exercise injects in KFEX. Evaluators are in charge of recording time value at checkpoints. Evaluators in KFEX 2007 used paper-based time check to observe and synthesis results. In order to reduce heavy tasks of evaluators and increase accuracy of record time value, KFEX 2014 applied software of Infogram Inc. to support for evaluators and controllers in the exercise. Several time elements were measured in KFEX under concept from Kitakyushu Fire Department

(2008). Start time of a task is defined as the time when an actor (group) began to act after it received information from the preceding actor (group) in the communication structure. End time is defined as the time when the actor (group) completed the task. Task processing time was the difference between the end time and the start time. Elapsed time was defined as the length of time between the start time of a task and the beginning of the exercise. Note that one group may conduct some different tasks simultaneously or sequentially in order to respond to the information sent to the group; these tasks had the same elapsed time. Moreover, the workflow can divide to servals of stage in task process. Explanation of time metrics and stages is shown in Figure 5-3.

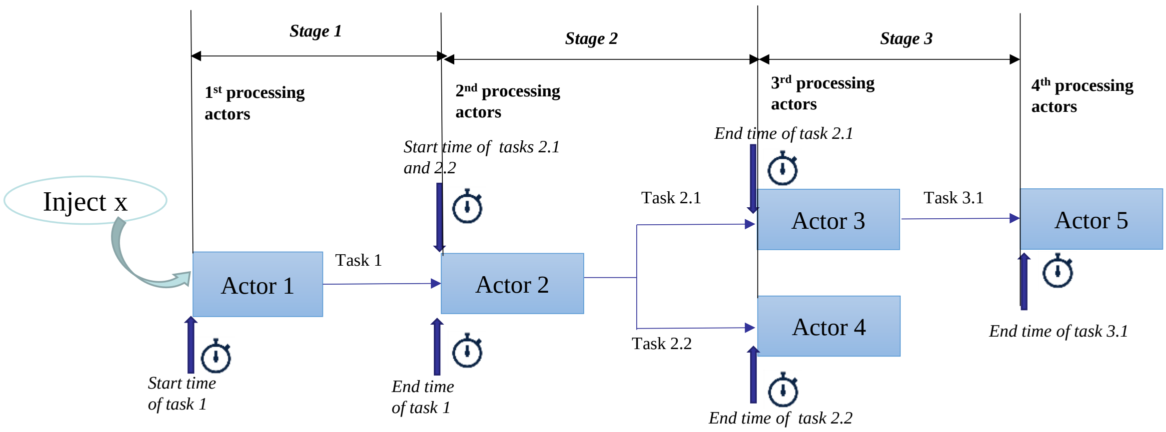
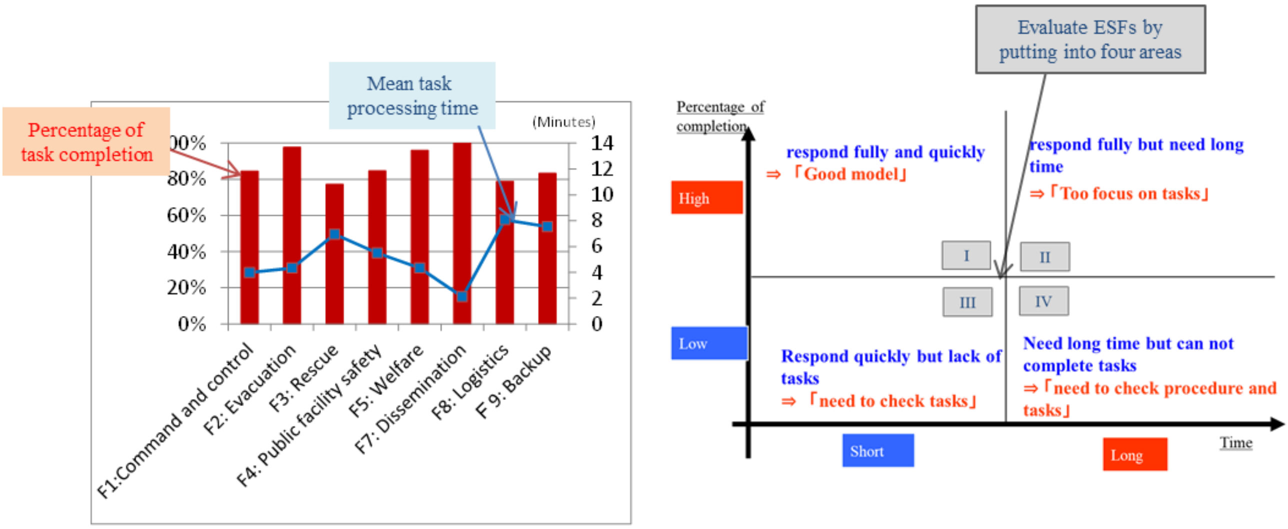


Figure 5-3: Time metrics and stages in workflow

In KFEX 2007, exercise program used time element to understand performance of ESFs in exercise. There were 9 ESFs in the KFEX 2007, in which each ESF includes a number of tasks that were conducted by players. Exercise evaluators calculated mean processing time and percentage of task completion for each ESF, then transferring results to four areas in axis format in Figure 5-4. From axis format, some suggestions for each ESF were delivered. It is noted that evaluation program in KFEX, 2007 evaluated ESFs other than how each stakeholder or organization performed in exercise. Tasks in one ESF can be conducted by several organizations. Therefore, if functional exercise is designed for specific ESFs (medical emergency support, firefighting and rescue,…), it is necessary to develop more detail methods to use time element in evaluation program.



Sources: Adapted from Kitakyushu Fire Department, After Action Report, 2008

Figure 5-4: Evaluation method in KFEX 2007

5.3. Research objectives and Data

Since there is still lack of quantitative evaluation methods in functional exercise, the chapter is designed to focus on this topic. Checklists are common evaluation methods of Functional exercise in the United State while time element was used in evaluation program in Kitakyushu functional exercise (KFEX). For KFEX style, task processing time is measured for each player group during exercise. The idea to breakdown emergency job into tasks of Kitakyushu Fire Department is important knowledge from KFEX style exercise. However, it is still high potential development of more details methods to analyse task processing time for each group in functional exercise.

Different from evaluation program of KFEX, my concern is to compare differences on task processing time among groups and task types in functional exercise. Detail investigation on task processing time of each player group can provide clues for emergency mangers about relationship among time, tasks and groups. Two specific research objectives on this chapter:

1. To develop methods to use data in functional exercise for understanding relationship among time, tasks and groups.

2. To apply methods to three case studies of functional exercise (two cases in Japan, and one case in Vietnam).

We were able to collect data from four functional exercise in both Japan and Vietnam. Data of functional exercises in japan were collected from three exercises conducted in October and November, 2015, December 2016 by the Disaster Medical Operation

Center (DMOC) in Kitakyushu city, Japan. These exercises simulated damages to the city caused by an earthquake with 6.9 Richter magnitude scale. Case study in Vietnam is functional exercise organized by Haiphong Firefighting Police Division (FFPD) to respond a chemical warehouse fire accident.

5.4. Develop methods in evaluation program

5.4.1. Process mapping technique

Relationship among groups in exercise is visualized in process map by process mapping techniques with linked tasks to each other. There are several of process map such as flowchart, process flowchart, process chart, functional process chart, functional flowchart, process model, workflow diagram. The purpose of process mapping is for organizations and stakeholders to improve efficiency of their operation. In practical, process maps provide insight into a process, help participants as well as emergency managers brainstorm ideas for process improvement, increase communication and provide process documentation.

Both general process and detailed process maps can help organizations and participants in exercise understand better about their networks. By reviewing general process maps, we can define which pairs of group have more communication in emergency response. One idea of general process map is Sociogram in Social Network Analysis in Chapter 3 of the thesis. Another idea is to make general process map more clearly by considering stages of task in communication structures. Detailed process maps can be constructed by visualize the connection task process for exercise's inject. The process map in each inject shows information about who connect with who, how many expected tasks for each group, what is content of task need to be done. This detailed information can be used for deeper review communication structures among groups in each inject.

5.4.2. Task performance analysis

To conduct statistical analysis for task processing data and influence factors, it is necessary to define task types and factors affecting task-processing time.

I defined task types in order to compare task processing time across those types. I referred to communication studies to classify tasks. First, in work and organizational psychology, an integrated method of task analysis is hierarchical task analysis (HTA), which was introduced by J. Annett & Duncan (1967). One of the HTA categories used for analyzing teamwork is "communication" and three observable actions in this category are "Send information," "Receive information," and "Discuss" (John Annett et al., 2000). Second, Habermas (1979) distinguishes "task-oriented" and "relationship-building" as two types of communication among groups. The first category refers to when a speaker contact a listener to request certain actions toward goals, while the second category is oriented toward sharing common information and understanding. I examined group tasks in the DMOC exercises and created four task types that were used for statistical analyses in the next section. The four task types are:

- "Request" refers to actions that send information to other groups to request certain actions toward goals. This is to send information in a task-oriented manner.
- "Report" refers to when a group sends information to others in order to share information and understanding. This is to send information in a relationship-building manner.
- "Inquiry" is defined as when one group collects or receives information from other groups in order to conduct subsequent tasks.
- "Decision making" is defined as a set of actions in one group that includes discussion, making decisions, delegating decisions to other groups. This task includes making discussions among relevant players.

There are team performance factors that should affect the task processing time. Often-cited models of team performance for meeting targets include Mac Grath, (1970), Gladstein (1984), and Hackman (1987). All of these models follow the basic concept of the input-process-output sequence. There are common factors included in these models, although each model has some unique additional factors. Three input factors including individual, team, and environmental levels found in McGrath's model were considered as potential factors regarding task processing time in FX. The temporal phase of the exercise was added as another potential factor (Jex & Britt, 2014). Elapsed time and stage in communication network were the variables to proxy this temporal phase factor. Table 5-2 summarizes the factors extracted from these studies that are potential factors affecting task processing time. Availability of observed data in FX for specific case studies will be checked before applying for multiple regression analysis in next sections.

Table 5-2. List of factors affecting task-processing time

Potential factors affecting task-processing time	
Individual-level	Member skills and training
	Personality characteristics of team member
Group-level	Structure of group
	Level of cohesiveness
	Group size
Environmental-level	Task characteristic
	Level of heavy workload at a particular time
Temporal phase	Stages of team project

To analysis data on task processing time, we proposed approaches for two type of time data. First type of data is statistical analysis for time data as cross-sectional data from an individual exercise. Second type is statistical analysis for time data as panel data from repeated tasks in two exercises. Panel data sometimes referred to as longitudinal data that track task processing time of same tasks different points in exercise events. A general diagram of statistical data analysis is shown in Figure 5-5

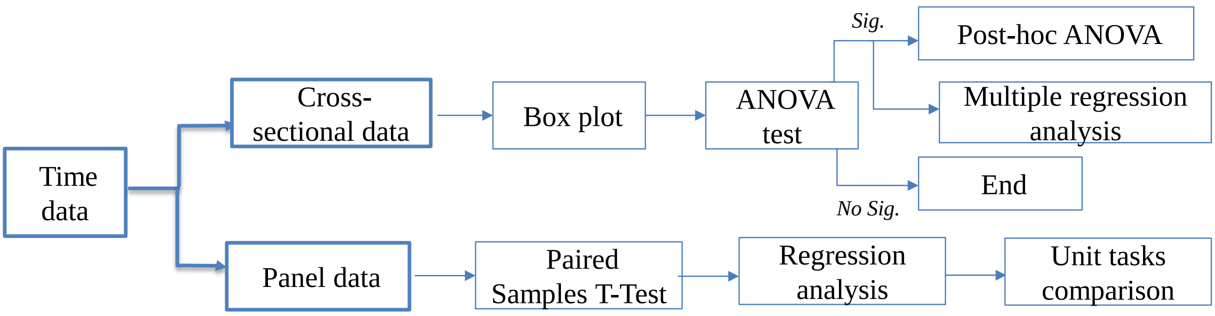


Figure 5-5: Diagram of Statistical Data Analysis

Details of each method/technique for statistical analysis are follows

a, For cross-sectional data in individual exercise

- Box plot a method for graphically depicting groups of numerical data through their quartiles including median, upper and lower quartile, whiskers. Box plots hep exercise evaluators exploring characteristic of task processing time and pointing out abnormal results as outliers. From that information, reason behind abnormal task processing time in dataset can be revealed.

- One-way analysis of variance (ANOVA) is well known method to determine whether there are any statistically significant differences between the means of more than two independent variables. There are several of groups and task types in FX so that ANOVA is useful method to test differences on the means of task processing time among exercise groups, and among task types. The hypothesis of ANOVA test is "H_0: there is no difference among means of task-processing time". If the significance p value is <=0.05, the test rejects H_0. It means there are different among the means of variables. In that case, we can do post-hoc ANOVA (Turkey's test) to explore additional differences among variables, and multiple regression analysis. On the other hand, if p value >0.05, it accepts H_0 that means no statistically significant difference among the means of task processing time. Statistical analysis for time data is stopped at this case.

- Multiple regression analysis is applied to analyze relationship between task processing time and influence factors. Linear regression is a common statistical data analysis technique. It is used to determine the extent to which there is a linear relationship between a dependent variable and independent variables. Multiple linear regression is applied in case of more than one independent variables. Multiple linear regression equation is shown as follows:

$$y = ax_1 + bx_2 + \cdots + c$$

Where y is a dependent variable, x is independent variable, a and b are regression coefficients or slopes, and c is intercept level of y.

If the p-value of the regression model is smaller than 0.05, there is a significant difference, and it means the independent variable affects the dependent variable.

In regression analysis model, task processing time of groups is dependent variable, and other factors might affect to task-processing time are independent variables. The dependent variable must be measured on a continuous measurement scale (e.g. task processing time) and the independent variables can be measured on either a categorical (e.g. task types, exercise group) or continuous measurement scale. In the case of the independent variables are measured as categorical data, dummy variables are used in regression model. Meanwhile dependent variable as task processing time can be observed fully or partially. Normal multiple linear regression is used for fully observation of dependent variable, while censored regression analysis can be used if the observed value of dependent variable is partially known. For censored regression analysis, the dependent variable is separated in point data, interval data, left or right censored data. In FX, there is some cases that task processing time can not fully measured. I apply this advanced regression analysis to use as many as possible observed data in FX. If there are unfinished tasks until end of exercises, we use results of time measurement for these tasks as right-censored data. For example, we have a sample of size n, of which n_1 observations are the exact values y known of task-processing time, $n_2= n - n_1$ tasks are defined only those time-values greater than a constant c. There are two type of data: point data for n_1 samples ($y = [y_{n1}, y_{n1}] = y_{n1}$) and right-censored data for n_2 samples ($y = y_{n2} = [c, +\infty]$). For other information of censored regression models, please refer in Maddala (1983).

b, For panel data of repeated tasks in exercises

- Paired samples t-test compares two means that are from the same individual, object, or related units. The two means typically represent two different times (e.g., exercise 1 and exercise 2 with task processing time is recorded for each repeated tasks). The purpose of the test is to determine whether there is statistical evidence that the mean difference between paired observations on a particular outcome is significantly different from zero. The paired samples t Test is a parametric test. The null hypothesis (H_0) assumes that the true mean difference is equal to zero. If the p-value (corresponding to the given test statistic t) is <=0.05, the test rejects H_0 with 95% confidence interval. That means there was a significant average difference between task processing time in two exercises. The test statistic for the Paired samples t-test , denoted t, follows the formula:

$$t = \frac{\overline{y1 - y2}}{\frac{S_{diff}}{\sqrt{N}}}$$

Where $\overline{y1 - y2}$ is the mean value of the difference between the two results at time 1 and time 2. S_{diff} is the standard deviation of the difference between the two results, and N is the number of data.

- Regression analysis for panel data: For repeated tasks for different exercises, set of data on task performance time is panel or longitudinal data. A panel has the form:

$$x_{it}, \quad i = 1,\dots, n, \quad t = 1,\dots ,T$$

Where i is panel variable as task ID that identifies corresponding data of each repeated task, while t is the time dimension for time point of exercises. A panel data regression model is

$$y_{it} = \alpha + \beta x_{it} + v_i + \varepsilon_t$$

Where y_{it} is task processing time of task i at the t time, $x_{it}$is a dependent variables that includes both time-varying and time-constant variables, x is an independent variable, α is constant term, v_i is individual specific, or time invariant effect whereas ε_t is a time varying random component.

The null hypothesis H_0 of "no effect" from independent variable to dependent variable. It rejects the null hypothesis at the choice of significance level 5%.

- Tasks comparison: Difference on task processing time of each repeated tasks at different period can visualized on chart for more detail discussion.

A summary of methods that can be used for understanding better relationship among time, tasks, and groups is shown in Figure 5-6.

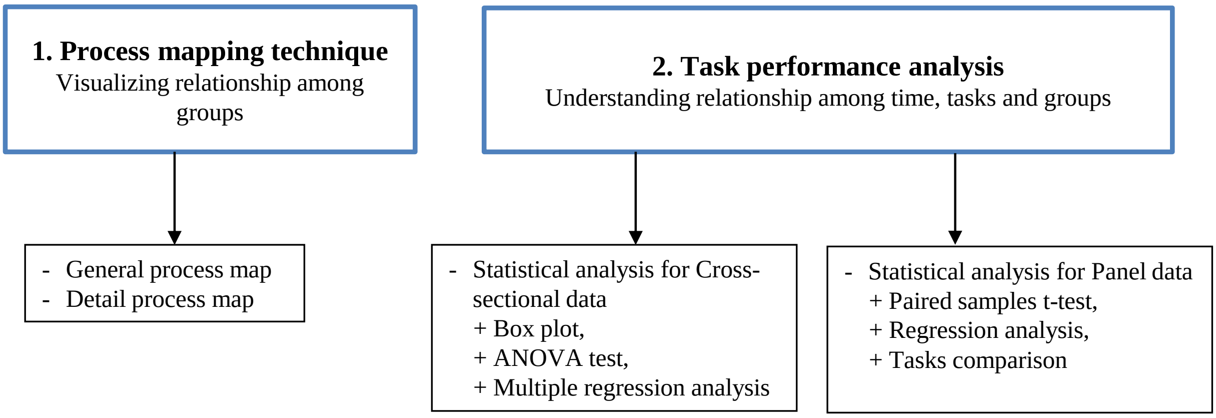


Figure 5-6: Methods to analyse data from Functional exercise

5.5. Case study 1: Functional exercises in 2015 at Kitakyushu city

5.5.1. Overview of 2015 DMOC exercises

Kitakyushu is an industrial city with a population of one million inhabitants that borders the northern region of Kyushu Island in Japan. The main types of natural hazards that threaten Kitakyushu include floods, typhoons, landslides, and earthquakes. Although the city has not suffered from major disasters in the last 50 years, several major disasters occurred in the city's neighbourhoods due to earthquakes in Kumamoto in 2016 and heavy rain in Northern Kyushu in 2017. Disaster preparedness is necessary for the city in order to reduce damage during disasters, as well as to support other cities.

The Kitakyushu Medical Association (KMA) and the local government have been developing a medical communication and resource management system for emergency situations. The KMA's Emergency Medical Plan (EMP) provided a framework for communication among medical stakeholders in Kitakyushu. The DMOC was established to coordinate medical organizations including hospitals and the KMA to meet various medical needs during disasters. Under supervision by the city's EOC, the DMOC cooperates with other stakeholders to allocate appropriate medical resources. As plan, when a disaster occurs, six groups of the DMOC gather at the Kitakyushu City

Yahata hospital, which is the city's disaster base hospital. There is one general coordination group and five specialized groups including "Site," "Base Hospital," "Shelter," "Logistic," and "Reinforcement" groups. "Site," "Base Hospital," and "Shelter" groups are in charge of communicating with corresponding organizations in these areas. The "Logistic" group distributes equipment and goods to shelters, medical facilities, and disaster sites. The "Reinforcement" group responds to disaster response support offers from outside organizations. The leader of the DMOC is the director of the Disaster Medical Training Center of Kitakyushu City Yahata hospital. Members of the DMOC are from the KMA, city government and other medical organizations. Figure 5-7 shows structure of DMOC.

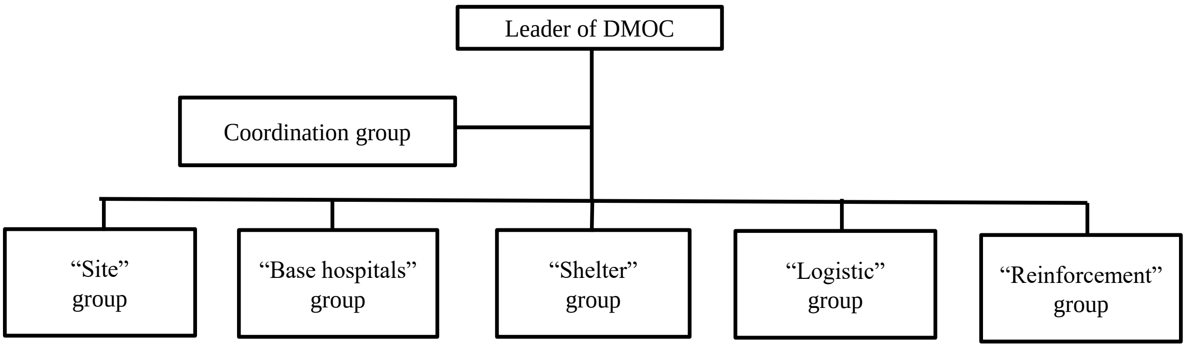


Figure 5-7. Structure of DMOC

Functional exercises are specified in the EMP as an important program to improve the awareness of related personnel and enhance coordination mechanisms among stakeholders in Kitakyushu. Through experiencing unusual situations in simulated exercises, participants can improve their readiness for an emergency as well as review and update existing plans and operations [12 Kohriyama, K.; Shigehito, I.; Takaaki, K. Saigai iryo ni hitsuyona hinichijyosei]. On October 27 and November 21 in 2015, two functional exercises were conducted in Kitakyushu City Yahata hospital to simulate medical emergencies. These exercises simulated damages to the city caused by an earthquake with a magnitude of 6.9 on the Richter scale. The assumed earthquake and its damage to the city were the same between the two exercises. Section 1 simulated the situation immediately after the earthquake, and the initial set up of the DMOC was the major activity during this section. Section 2 simulated the situation in which the DMOC coordinated medical activities in evacuation shelters and other locations. In DMOC exercises, the player team was separated into five groups: Coordination Group, Site Group, Base Hospital Group, Shelter Group, Logistics Group. These groups were in charge of responding to injects delivered from the controller team via telephone. There were one evaluator for each player group as well. Evaluators were in charge of observing start and end time of each task by using software of Infogram Inc. Task processing time was observed for tasks in emergency injects. Total 21 participants were allocated in player groups for both the exercises.

5.5.2. Data and analysis methods

Data on task processing time for each task in emergency injects were collected in both Oct and Nov exercises of DMOC. Several measures of time were recorded in DMOC exercise. Start and end times of each task were recorded by evaluators using an exercise evaluation software developed by Infogram Inc. Start time of a task was defined as the time when a group began to act after it received information from the preceding group in the communication structure. End time was defined as the time when the group completed the task. Task processing time was the difference between the end time and the start time. Elapsed time was defined as the length of time between the start time of a task and the beginning of the exercise. Task processing time of each group in both October and November exercises has been collected. There were 17 emergency injects in October and 18 in November. DMOC groups needed to complete more than one task to find a solution to an exercise inject. Thus, a total of 57 tasks and 59 tasks were conducted in October and November, respectively. These two exercises had the same 39 tasks. Three tasks in October and five tasks in November remained incomplete until the end of the exercise. I were unable to ascertain the end time and task processing time for these tasks. Main information of DMOC exercises is shown in Table 5-3.

Table 5-3. Overview of 2015 DMOC functional exercises

Item	**Oct exercise**	**Nov exercise**
Time	27^{th} October 2015 from 13:00 to 15:20	21^{st} November 2015 from 8:00 to 10:20
Scenario	Earthquake occurred with epicentre in district Kokura, Kitakyushu city on *[date, time]*, magnitude of 6.9 on the Richter scale	
Number of injects	29	30
Number of emergency injects	17	18
Total number of task in emergency injects	57	59

Number of tasks have not been finished at exercise end	3	5
Repeated tasks between two exercises	39	
Number of players in DMOC *(as counted in record picture of exercise)*	Co-ordination 5 Site 4 Base hospitals 3 Shelter 5 Logistics 4	Co-ordination 5 Site 3 Base hospitals 4 Shelter 6 Logistics 5

In DMOC exercises, five player groups were arranged as follows: "Coordination", "Site," "Base Hospital," "Shelter," "Logistic" groups. It is note that these groups act together at operation center to share and receive information from various stakeholders. Name of group, for example, shelter group implies main mission of this group is to communicate with shelter forces. That not means that group work as field responders at shelters. Moreover, in both exercises, logistic and reinforcement members were arranged in one group namely "Logistic" group. Layout of DMOC exercise in October and November 2015 is shown in Figure 5-8.

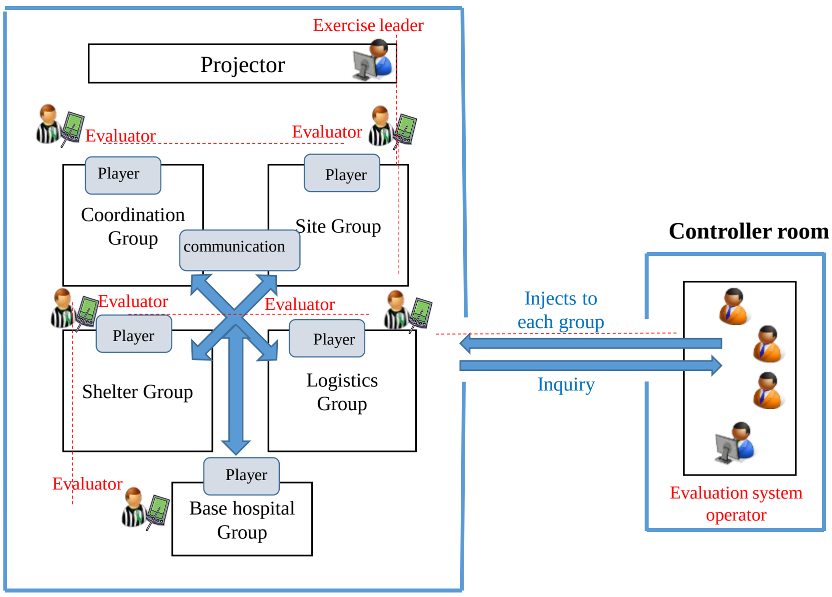


Figure 5-8. Layout of DMOC exercise

As mentioned in Section 5.3.2.2, four task types are "request", "report", "inquiry", and "decision making". By reviewing content of each task in DMOC exercise, we classified tasks into relevant types. Moreover, regression analysis for exercise data requires hypothesis of influence factors to task processing time. Influence factor related to observed data in DMOC exercises is shown in Table 5-4. Because some factors were not observed in the DMOC exercises, "DMOC group" variable reflected several dimensions of each group such as member skills, member characteristics, and group cohesiveness. Since the number of group members was perfectly correlated with the dummy variables of the "DMOC group," this variable was excluded from the analysis to avoid multicollinearity. Independent variables in multiple regression model is explained in Table 5-5.

Table 5-4. List of factors affecting task-processing time

Potential factors of task-processing time		**Availability of data in DMOC exercises**
Individual-level	Member skills and training	*Not observed*
	Personality characteristics of team member	*Not observed*
Group-level	Structure of group	Communication domain
	Level of cohesiveness	*Not observed*
	Group size	Number of members in each group
Environmental-level	Task characteristic	Task types
	Level of heavy workload at a particular time	Number of simultaneously processed tasks in a group
Temporal phase	Stages of team project	Elapsed time
		Stage in communication structure

Table 5-5. Independent variables in multiple regression model

Variable	**Variable types (unit)**
DMOC group	Dummy variable Coordination Site Base Hospital Shelter Reinforcement and Logistics
Communication domain	Dummy variable Within DMOC With outside groups
Task type	Dummy variable Report Request

	Inquiry Decision making
Simultaneously processed tasks	Countable number (piece)
Elapsed time	Continues number (second)
Stage in communication structure	Dummy variable Stage 1 Stage 2

Data from DMOC exercises include both cross sectional data for each individual exercise and panel data for repeated tasks in two exercises. Diagram of statistical data analysis as Figure 5-5 is applicable for database from DMOC exercises.

5.5.3. Results

5.5.3.1. Visualization of communication structures by process mapping technique

We draw general process map for each exercise that provide outline of how different groups connect to others in exercise. Figure 5-9 shows communication structure for October and November exercises featuring all emergency exercise injects.

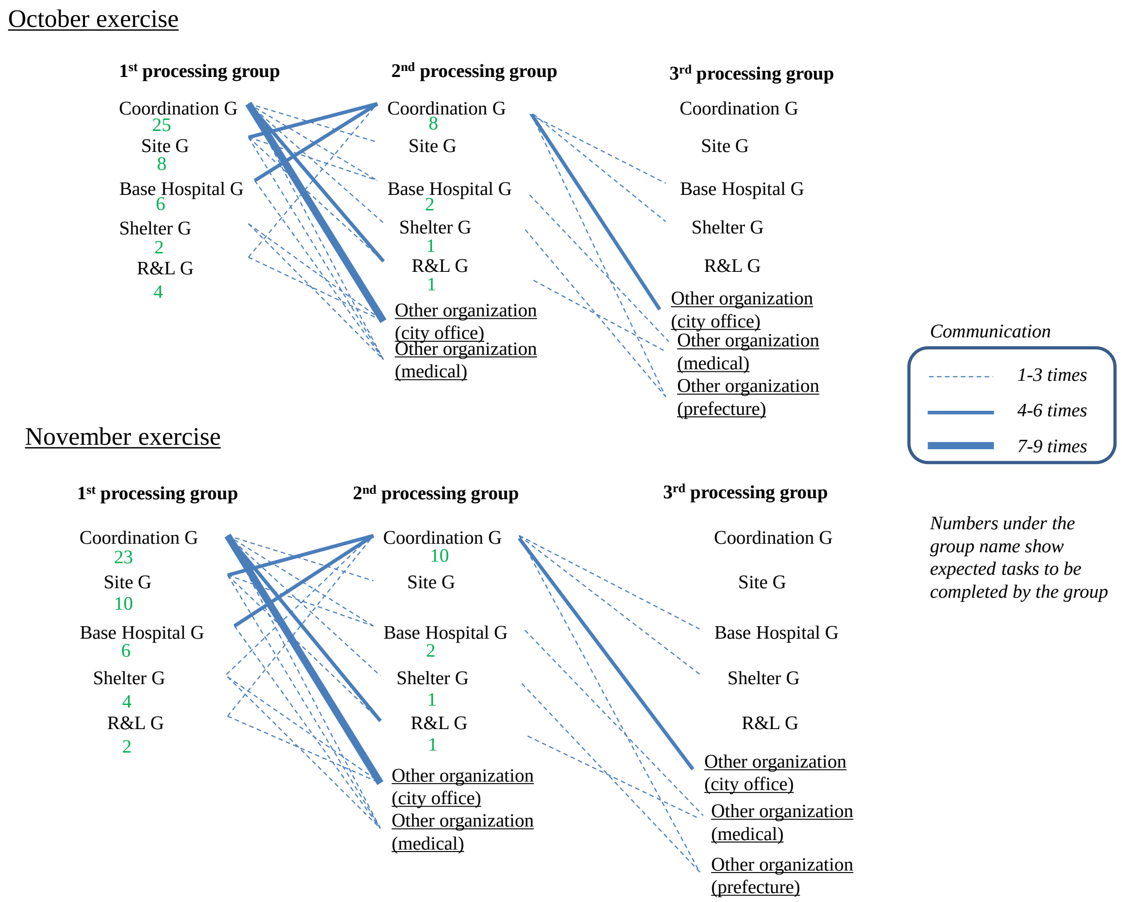


Figure 5-9. Overall communication structures of the two exercises

From general process maps, we were able to identify important partners of each group to complete their tasks reflecting by number of communication times. By reviewing these maps, participants of exercises can better understand which organization is their main partner in earthquakes. The coordination group and other organizations of Kitakyushu city office had highest number of communication times in both exercises. The coordination group worked as a hub of communication among player groups. These two process maps also show that the patterns of the communication links among the player groups were the same between the October and November exercises reflecting the fact that a majority of the exercise injects were identical between these exercises.

For each inject in exercise, by combining communication structures and result of measuring task processing time, detail information of task implementation is created in detail process map. An example of detail process map is shown in Figure 5-10 for Inject 19 in October exercise. It provides basic information on communication structure including implementation groups, content of tasks, links and task processing time by seconds.

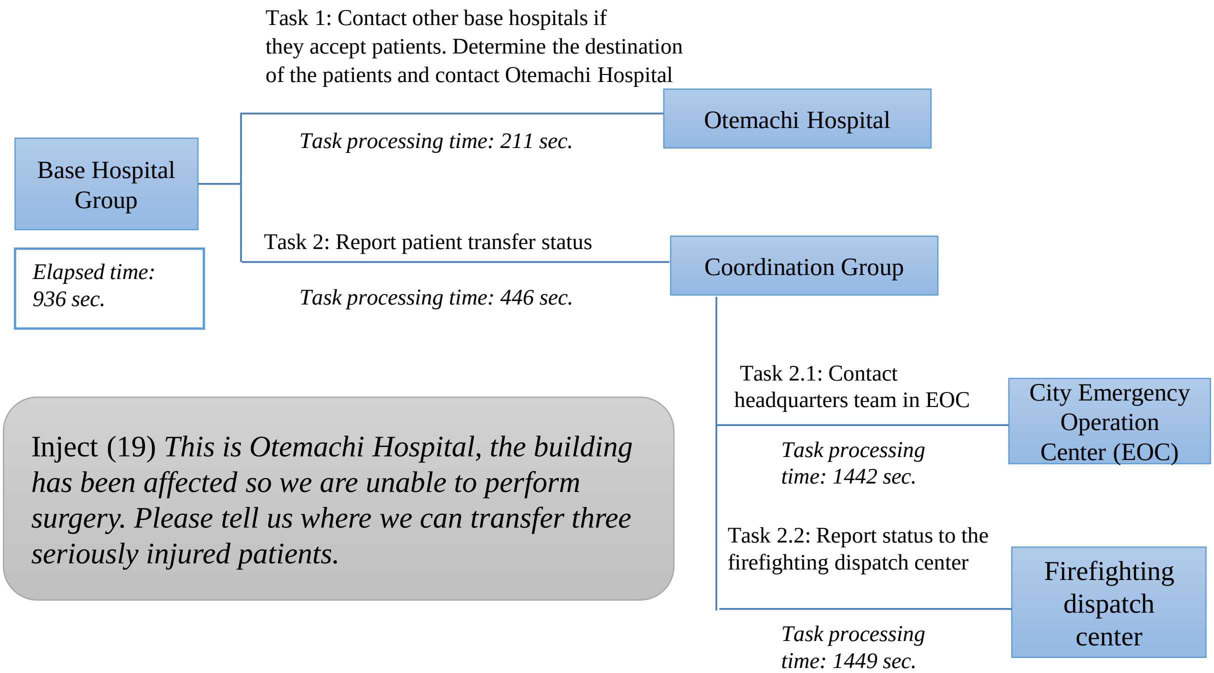


Figure 5-10. Detail process map for inject 19 of the October DMOC exercise

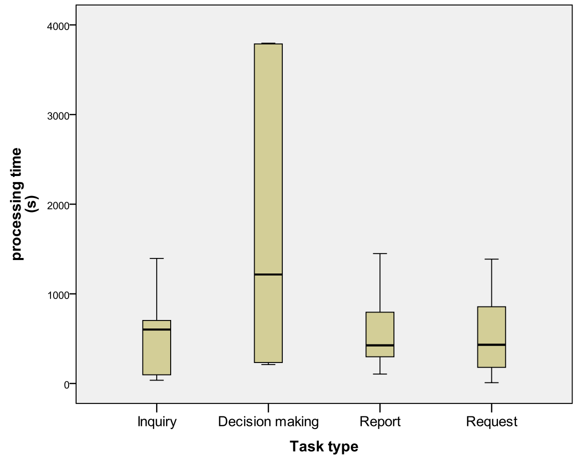
5.5.3.2. Task performance analysis by statistical data analysis

a, For cross-sectional data in individual exercise

<u>Analysis of the October exercise</u>

Firstly, box plots are used to show the distribution of task processing time among five groups and four task types in this exercise. The minimum, first quartile, median, third quartile, and maximum value of the data are displayed. Figure 5-11 summarizes the task-processing time for task types and DMOC groups.

Task types

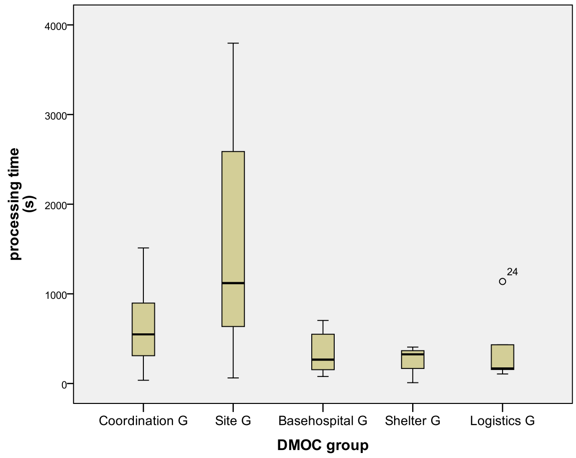


Task type	N	Mean (sec)	Std. Deviation (sec)	Min (sec)	Max (sec)
Inquiry	9	528.00	448.295	36	1395
Decision making	6	1743.67	1658.311	211	3796
Report	22	581.05	417.021	105	1449
Request	17	573.47	437.936	9	1387
Total	54	699.00	745.597	9	3796

Statistical test	p-value
ANOVA	0.020*

**. The difference is significant at the 0.05 level*

DMOC groups



DMOC group	N	Mean (sec)	Std. Deviation (sec)	Min (sec)	Max (sec)
Coordination	30	658.0	438.81	36	1512
Site	8	1568.0	1437.44	62	3796
Base Hospital	8	340.0	238.54	78	703
Shelter	3	247.0	209.96	9	406
Logistics	5	399.8	431.83	106	1138
Total	54	699.0	745.59	9	3796

Statistical test	p-value
ANOVA	0.030*

**. The difference is significant at the 0.05 level*

Figure 5-11. Task-processing time across task types and DMOC groups in the October exercise

Since the p-value of ANOVA for task processing time was smaller than 0.05, the post-hoc ANOVA (Turkey's test) was applied to compare mean values among task types and DMOC groups. Then, at the 5% significance level, "decision making" took more time than the other three task types, and "Site Group" took more time to process their tasks than the other four groups (Table 5-6).

Table 5-6 Multiple Comparisons using post-hoc ANOVA for October exercise

Type of task	Type of task	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Decision making	Inquiry	1215.667*	350.225	0.006	284.91	2146.42
	Report	1162.621*	306.049	0.002	349.27	1975.97
	Request	1170.196*	315.546	0.003	331.61	2008.79
Type of Group	**DMOC groups**	**Mean Difference**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Site G	Co-ordination G	909.933*	262.227	0.009	167.32	1652.55
	Base hospital G	1228.000*	329.505	0.004	294.86	2161.14
	Shelter G	1321.000*	446.151	0.036	57.53	2584.47
	Logistics G	1168.200*	375.693	0.025	104.26	2232.14

Dependent variable: processing time(s) **. The difference is significant at the 0.05 level*

To examine the relationship between task processing time and multiple factors of group performance, we estimated a censored regression model. In the October exercise, we measured the task processing time of 54 tasks as uncensored samples, and three unfinished task times were treated as right-censored. With regards to the independent dummy variables of the task type, "decision making" is chosen as the baseline for comparison, "Site Group" is chosen as the baseline for the DMOC group dummy variables, and "Communication with outside groups" as the baseline for Communication domain, "Stage 2" as the baseline for stage in communication structure. Other independent variables were defined as shown in Table 5-5. Robust standard errors were used in making inferences to address possible heteroscedasticity across observations. The result of censored regression analysis for the October exercise is summarized in Table 5-7. Coefficients of the three task types were negatively and statistically significantly different from that of the baseline of "decision making." Thus, the task processing time spent on decision making took longer than the time spent on inquiry, report, and request. The Base Hospital and Shelter groups took less time than the Site group to finish their tasks. The positive coefficient of the variable "Stage 1" indicated that the tasks in Stage 1 were finished quickly than those in Stage 2.

Table 5-7. Censored regression analysis for October exercise

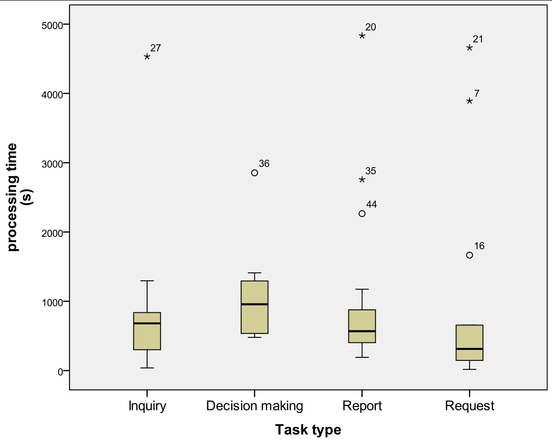
Variable	Coefficient	p-value
Constant	1746.0**	0.000
DMOC groups		
Base Hospital Group	-1153.9**	0.004
Shelter Group	-840.0*	0.023
Logistics Group	-630.0	0.117
Coordination Group	-618.9	0.072
Communication domain (within DMOC)	482.5	0.053
Task type		
Inquiry	-1063.4*	0.012
Report	-855.2**	0.005
Request	-1186.3**	0.008
Simultaneously processed tasks	35.0	0.326
Elapsed time	0.004	0.942
Stage (Stage 1)	-758.5*	0.017
Number of observations	57	
Uncensored/right-censored	54/3	
Wald chi-square (11)	29.39, p=0.002	
Log pseudo likelihood	-425.221	

* *p* $\leq$ *0 .05; ** p <0 .01.* Dummy variable base line: Site Group, with outside group, Decision making, Stage 2.

Analysis of the November exercise

Figure 5-12 shows the results of applying the same analysis procedure to the November exercise. Task processing time of 54 finished tasks and five tasks unfinished until the end of the exercise were used as data sources. As we can see from the box plots, task processing time in the November exercise had more outliers than in the October exercise. ANOVA test did not detect statistically significant differences at the 5% level among the mean of task processing time across task types or DMOC groups. Since no statistically significant differences after ANOVA test, we did not apply censored regression analysis for November exercise. By analyzing time data between two exercises, it proves that the characteristics of communications across the player groups changed between the October and November exercises. This difference between the two exercises was difficult to detect without an application of quantitative analysing time data.

Task types

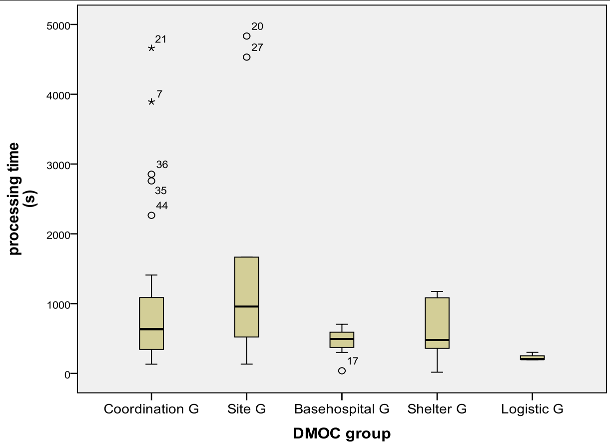


Task types	N	Mean (sec)	Std. Deviation (sec)	Min (sec)	Max (sec)
Inquiry	10	983.70	1297.00	38	4532
Decision making	8	1113.25	782.40	479	2854
Report	22	929.68	1074.29	191	4834
Request	14	947.57	1475.06	17	4661
Total	54	971.52	1166.80	17	4834

Statistical test	p-value
ANOVA	0.986

**. The difference is significant at the 0.05 level*

DMOC groups



DMOC groups	N	Mean (sec)	Std. Deviation (sec)	Min (sec)	Max (sec)
Coordination	28	1039.0	1169.52	132	4661
Site	10	1590.4	1687.29	133	4834
Base Hospital	8	456.3	207.26	38	704
Shelter	5	622.6	493.40	17	1174
Logistic	3	234.0	59.02	196	302
Total	54	971.5	1166.80	17	4834

Statistical test	p-value
ANOVA	0.190

**. The difference is significant at the 0.05 level*

Figure 5-12. Task-processing time across task types and DMOC groups in November

Analysis of repeated tasks in October and November exercises

- The mean difference between paired task processing time of 39 repeated tasks in two exercises were compared. The result of paired samples t-test shown in Table 5-8

Table 5-8. Paired samples t-test between two exercises

	October exercise	November exercise
Processing time mean (s)	601.67	699.41
Number of repeated tasks	39	
p-value	0.347	

Mean value of task processing time in November is longer than October exercise. Checking p-value = 0.347 > 0.05 means that there was no significant difference between processing time for same task between two exercises. More details of investigation for time data between two exercises are explained in next sections.

- Panel data: For 39 repeated tasks between October and November exercises, it creates 78 observations for longitudinal data regression model. This model is used to consider influence of independent variables on task processing time. Independent variables include implementation phase, time elapsed, dummy variables of task types, dummy variables of DMOC groups, communication domain, stage, and number of branch. The dummy variables base line is same as the censored regression analysis in October exercise. Table 5-9 shows that there is statistically significant in different of "stage of task" for panel data from two exercises. It reveals that tasks in stage 1 took less time than task in stage 2. It is also statistically significant in difference of variable "communication domain" in both exercise. Communication inside DMOC groups took more time than communication outside groups.

Table 5-9. Random effects regression model for Oct and Nov exercises

Task processing time	Coef.	Robust Std. Err.	P value	[95% Conf. Interval]	
Constant	939.495	499.221	0.060	-38.961	1917.951
Implementation phase (Oct or Nov)	111.116	112.550	0.324	-109.478	331.709
DMOC groups					
Coordination Group	-136.614	311.190	0.661	-746.535	473.307
Base hospital Group	-427.682	354.643	0.228	-1122.768	267.405
Shelter Group	151.374	385.367	0.694	-603.932	906.680

Logistics Group	-564.860	381.644	0.139	-1312.870	183.149
Communication Domain (within DMOC)	329.864*	127.245	0.010	80.468	579.259
Task type					
Inquiry	-560.175	298.151	0.060	-1144.540	24.191
Report	-390.884	294.388	0.184	-967.873	186.106
Request	-442.352	383.777	0.249	-1194.541	309.836
Simultaneously processed tasks	14.868	29.047	0.609	-42.064	71.800
Elapsed time	-0.054	0.034	0.120	-0.121	0.014
Stage (Stage 1)	875.648*	218.608	0.000	447.184	1304.112
Number of observation	78				

$*p \leq 0.05$; $**p < 0.01$. Dummy variable base line: Site Group, with outside group, Decision making, Stage 2.

Since both stage of task and communication domain affect to result of task processing time, we investigated more detail of mean and median of task processing time for these observations. In Table 5-10, it clearly shows that more time was consumed to finish tasks in stage 2 than stage 1 while communication among groups inside DMOC took more time than communication outside DMOC.

Table 5-10. Differences of task processing time by task stages and communication domains in two exercises

Characteristic of tasks	Number of observation	Mean of task processing time (s)	Median of task processing time (s)
Tasks in stage 1	64	532.8	406
Tasks in stage 2	14	1188.7	1378
Communication inside DMOC	36	695.7	489.5
Communication outside DMOC	42	611.8	398

- In Figure 5-13, we compared the difference in task processing time of 39 repeated tasks between the two exercises by subtracting the task processing time in November from that in October. Different markers indicate different DMOC groups. The figure shows 32 tasks in Stage 1 and 7 tasks in Stage 2 separately. Markers connected by a solid line indicate that these tasks were started by the same group at the same elapsed time.

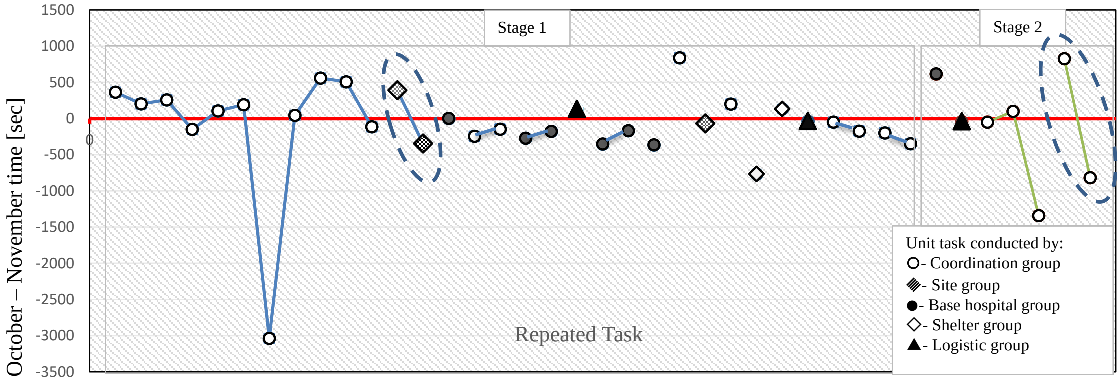


Figure 5-13. Differences in task-processing time for 39 repeated tasks

Figure 5-13 shows some curious results. In Stage 1, one task conducted by the Coordination group showed a significant difference in task processing time between the two exercises. This task was a response to inject 3 and the Coordination group was required to ask the Logistics group to send advance requests for reinforcement to the prefectural and national governments and to prepare an acceptance plan for those reinforcements. It took 856 and 3893 seconds to finish this task in October and November, respectively. The Coordination group might forget to perform this task immediately in the November exercise. Figure 5-13 also reveals that the Base Hospital group took more time to finish all tasks at Stage 1 in November than in October. Thus, repeating the exercise twice with a one month interval did not necessarily shorten the task processing time in these groups. There are cases in which the processing time of tasks started at the same time by the same group reversed results regarding time difference between October and November (see circled results in Fig. 5-13). The last two tasks on the right hand side of Figure 5-13 are an example of this. A detailed description of this task in response to inject 19 in October was shown in Figure 5-10. Task 2.1 “Contact headquarters team in EOC” and Task 2.2. “Report status to the firefighting dispatch center” were finished in 1442 and 1449 seconds, respectively in October. In November, Task 2.1 took 615 seconds and Task 2.2 took 2265 seconds. The total task processing time for these two tasks was approximately equal in the October and November exercises. This reverse of processing time difference between the two months may be a result of a change in prioritization over these tasks by the players. Thus, we were able to find clues about players’ thought and behavior by conducting this detailed time analysis of exercise results.

5.6. Case study 2: Functional exercise in 2016 at Kitakyushu city

5.6.1. Overview of 2016 DMOC exercise

On December 3, 2016, the exercise was conducted for medical teams in Kitakyushu city. The exercise simulated emergency response at the DMOC center and shelters. As a lesson learned from the 2011 Great East Japan Earthquake and 2016 Kumamoto earthquakes, the KMA emphasizes the necessity of smoother decision-making or coordination networks during emergency response. In total, 49 events were simulated in the two exercise sections: organizational arrangement and shelter response. In this exercise, 45 participants from various medical organizations formed 8 functional groups in the exercise room. The six DMOC groups shown in Figure 5-7 were merged into four groups, namely the coordination group, site and base hospital group, shelter group, and logistics and reinforcement group. Meanwhile, compared with two functional exercises in 2015, the scope of the one in 2016 was expanded to cover DMOC operations and activities at mock-up shelters by Japan Medical Association Teams (JMATs). In Japan, the key relief forces in providing medical care in a disaster are the Japan Medical Association (JMA) and physicians in disaster areas. The JMAT and Disaster Medical Assistance Team (DMAT) are two main forces that swiftly respond to medical service needs. JMAT and DMAT differ in terms of structure and roles. The government or prefectural governments designate DMAT teams. The main purpose of DMAT is to provide medical assistance in the acute phase, typically during the first 72 hours after a disaster. On the other hand, JMAT is organized by the JMA. JMATs typically consist of four members: one physician, two nurses, and one coordination staff member. The operation timeframe for JMAT ranges from three days to several months. Furthermore, the main activities of JMAT include providing healthcare at shelters and first-aid stations and assisting at hospitals in the disaster areas. In 2016 DMOC exericse, one Local Medical Association (LMA) group and three groups of JMATs (JMAT 1, 2, 3) were involved in this exercise.

As the general structure at the national level, JMATs are established by gathering members of the the Japan Medical Association (JMA) for one or two days after a disaster occurs in an area. Typically, these teams are mobilized from non-affected disaster areas to support afflicted areas by providing healthcare services at shelters. There is a need to provide support from outside the disaster area, since local medical forces are usually also damaged therein. As an innovation to quickly send medical teams to shelters before waiting for outside forces, the KMA would like to establish their own “JMATs” as soon as possible by gathering human resources inside Kitakyushu city. To practice and provide training in this regard in the 2016 DMOC exercises, two sections were conducted in the exercise. Section 1 simulated the situation after an earthquake occurs in Kitakyushu city, which requires the establishment of the DMOC. Section 2 simulated events at shelters in which JMATs made decisions and contacted other groups to provide healthcare services for evacuees. Medical students pretended to be evacuees with health problems in the mock-up shelters, and were medically diagnosed by the JMATs. The overview and layout of the 2016 DMOC functional exercise are described in Table 5-11 and Figure 5.14.

Table 5-11. Overview of the 2016 DMOC functional exercise

Item	Description	
Time	December 3, 2016; 15:30 to 17:00	
Scenario	Earthquake occurred with epicenter in Kokura district, Kitakyushu city at 14:00. Seismic intensity M 6.9 There are 429 deaths, 3,780 injuries, and 21,380 evacuees in 300 opened shelters.	
Number of players	Coordination group	5
	Site and base hospital group	3
	Shelter group	7
	Logistics and reinforcement group	4
	Local Medical Association	12
	JMAT 1/2/3	4/5/5
Number of controllers	6	
Number of evaluators	7	
Number of injects	49	
Number of tasks	111	

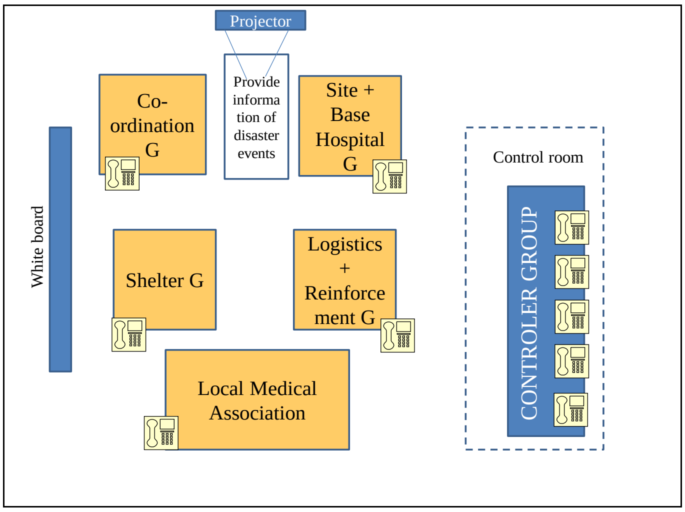


Figure 5-14. Layout of the 2016 DMOC and control room

5.6.2. Data and analysis methods

In 2016 DMOC exercise, since there were two sections including section 1- DMOC establishment, and section 2- JMATs at shelters. Section 2 of the exercise simulated events at shelters by JMATs. In the shelters, the main task of the JMATs was clinical diagnosis, during which they were required to identify evacuees' health conditions. As mentioned in Section 5.3.2.2, four task types of communication are "request", "report", "inquiry", and "decision making". By adding "clinical diagnosis" task in the 2016 DMOC exercise, five task types were investigated in this exercise.

To understand relationship among groups in the exercise, general process map is used to visualize communication structure. For each section in the exercise, the communication structure are created. After that, several techniques of statistical analysed are applied to quantitative analysis of task processing times across task types and groups. Since the number of task types and groups are more than two, we applied an ANOVA to test the mean value of task processing time among five task types and eight groups. The hypothesis of the ANOVA was "H_0: there is no difference among the means of task processing time." If the significance p value <=0.05, the test rejects H_0, indicating differences among the mean values of variables.

5.6.3. Results

5.6.3.1. Visualization of communication structures by process mapping technique

Communication structures among groups were created in the two sections of the DMOC exercises for all 49 injects. Figure 5-15 and Figure 5-16 show the communication structures among groups in Section 1 and Section 2. Based on these structures, we defined the important partners required by each group to fill in their tasks. Section 1 included 13 injects with 35 tasks related to the establishment and operation of the DMOC. These tasks were conducted by groups inside the DMOC groups, namely the coordination group, site and base hospital group, logistics and reinforcement group, shelter group, and other stakeholders. Other stakeholders are people from the city and prefecture-level offices who are also in charge of disaster response. We observed many communication times for the site and base hospital group, coordination group, and other stakeholders in Section 1 of the exercise. Section 2 simulated 36 injects with 76 tasks related to JMATs activities in the shelters. Communication structures among the JMATs and LMA became important in this section. The exercise highlighted the links between the JMATs and LMA as a core issue in a real disaster event. The relationship between the LMA and shelter group is also important in a disaster.

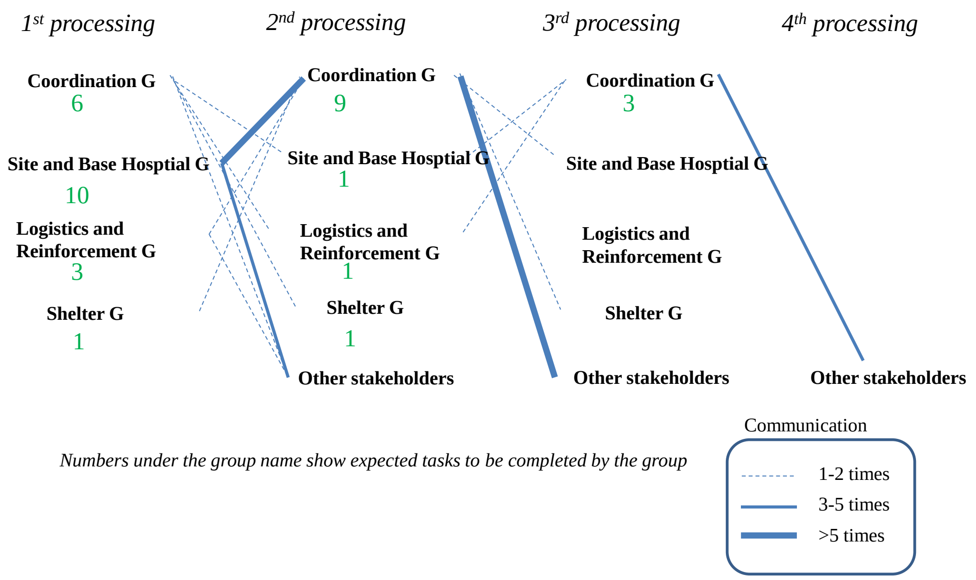


Figure 5-15. Communication network in Section 1: DMOC establishment

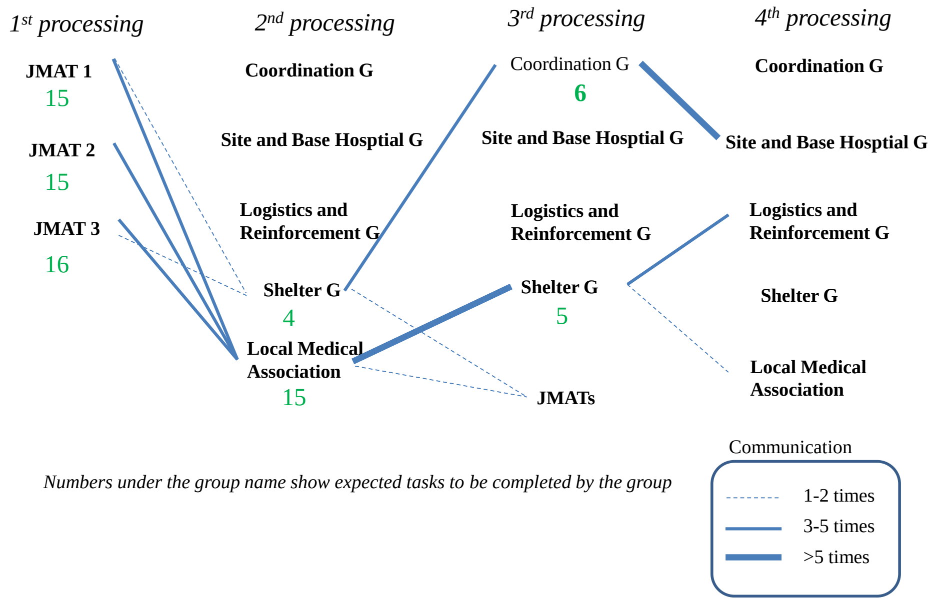


Figure 5-16. Communication network in Section 2: JMATs at shelters

5.6.3.2. Task performance analysis by statistical data analysis

From data recorded from 111 tasks in the 2016 DMOC exercise, ANOVA test was applied for understanding difference on mean value of task processing time for each task type and group. The hypothesis for ANOVA test was as follows: "The means of task processing time differ between task types and groups." ANOVA test of task processing time for the five task types did not detect statistically significant differences at the 5% level (p-value = 0.139). Meanwhile, the p-value of the ANOVA for task processing time for the eight groups was smaller than 0.05, indicating a statistically significant difference between the mean values of task processing time for groups. The results of the ANOVA test for groups are provided in Table 5-12.

Table 5-12. Means for task processing time across groups.

Groups	**N**	**Mean** (sec)	**Std. Deviation** (sec)	**Min** (sec)	**Max** (sec)
Coordination G	24	646.04	388.74	82	1490
Shelter G	11	314.82	465.39	93	1709
Logistics and reinforcement G	4	855.25	392.85	415	1238
Site and base hospital G	11	555.45	408.60	151	1425
LMA	15	341.47	486.42	36	1662
JMAT 1	15	245.20	186.87	1	586
JMAT 2	15	347.60	242.61	11	707
JMAT 3	16	993.50	653.012	56	2203
ANOVA test	Between groups: p-value = 0.000				

The results show that "JMAT 3" took longest time to finish their tasks in the exercise, meanwhile JMAT 1 need less time to finish their tasks. To better understand the results, we reviewed the tasks and characteristics of the three JMATs. Table 5-13 details the task processing times of these teams.

Table 5-13. Differences among task processing time of JMATs.

Task	**JMAT 1**		**JMAT 2**		**JMAT 3**	
	N	***Mean (sec)***	***N***	***Mean (sec)***	***N***	***Mean (sec)***
Inquiry	1	85	0	0	0	0
Report	2	224.5	2	34.5	3	421.0
Request	2	505.0	3	453.7	3	933.0
Clinical diagnosis	10	231.4	10	378.4	10	1183.4

JMAT 3 took more time to complete all four task types than JMAT 1 and JMAT 2. Clinical diagnosis was the main task type for the JMATs at the shelter. In the DMOC exercise, each JMAT had to perform a health check of ten evacuees. Different types of diseases were provided for each JMAT in this exercise. Thus, differences in complex diseases may have affected the task processing times of the three JMATs. The capability characteristics of members in the JMATs can affect to task processing time. Further suggestions to reduce the time consumption of each JMAT could be discussed with participants and medical professors after the exercises.

5.7. Case study 3: Functional exercises for Haiphong FFPD

5.7.1. Overview of Haiphong Functional exercise

Haiphong city is an important port city, industrial center and the largest seaport in the North of Vietnam. The geographical location of Haiphong has many advantages for economic development but it also prone of high risks of natural disasters and incidents. Together with process of industrialization and urbanization, Haiphong city faces with high risk of fire accidents. Total number of fire accidents was increasing from 205 cases in 2012 to 355 cases in 2016. During this period, number of fire cases were increased 1.5 times but property damage in 2016 was 5 times as high as it was in 2012. It reveals that more serious damage from larger fire scale in Haiphong city. Therefore, it requires better co-operation among local and professional forces, communities and relevant organizations in this field of firefighting and rescue.

The Haiphong FFPD is the main emergency relief organization for firefighting and rescue in Haiphong city. The organization is in charge of coordinating firefighting teams and affiliated units as well as connecting with related organizations. Before September 2018, Haiphong FFPD is one Department at city level. From September 2018, the division is merged becoming one division belong to Haiphong Department of Public Security. Main types of training practices in Haiphong FFPD are lectures and drills that focus on field responders in firefighting and rescue. Functional exercise that focuses on enhancing co-operation among forces in large disaster has not been conducted in the organization.

Haiphong Functional Exercise (Haiphong FX) was conducted from 9:00 to 11:00 in 21 January 2018. This was the first time of doing functional exercise as KFEX style in Vietnam. The scenario simulated a fire incident occurred at a chemical facilities (ThuongLy) in Hai Phong city. The content of the initial scenario was "In the Thuong Ly chemical warehouse, an explosion is occurred that leading to a fire in a 1000 m^3 Toluen tank that close to set of other 10 tanks (02 tanks of 1000 m^3 and 8 tanks of 500 m^3). After the first explosion, the cover of the tank burst out, the fire took place on the entire surface of the tank with an area of 95 m^2, and a large amount of Toluene was spilled out. Then, fire expands to other 50 m^2 around the dike at bottom of the tank. It is high risk of expanding fire to surrounding tanks."

There were three functional groups in exercise. Controller group is in charge of sending scenario, injects, and simulation other responses if necessary during exercise. Player groups included "Information Command Center" and "Field Commander." There were three members in each player group. Information Command Center is in charge of receiving and sharing information from different stakeholders, as well reporting to Fire Director. Field Commander is in charge of commanding field teams for firefighting and rescue. The highest-ranking office of FFPD on site plays as Fire Commander. There was one evaluator for each player group as well. Evaluators were in charge of observing start and end time of each task by using software of Infogram Inc. The layout of Haiphong FX is shown in Figure 5-17.

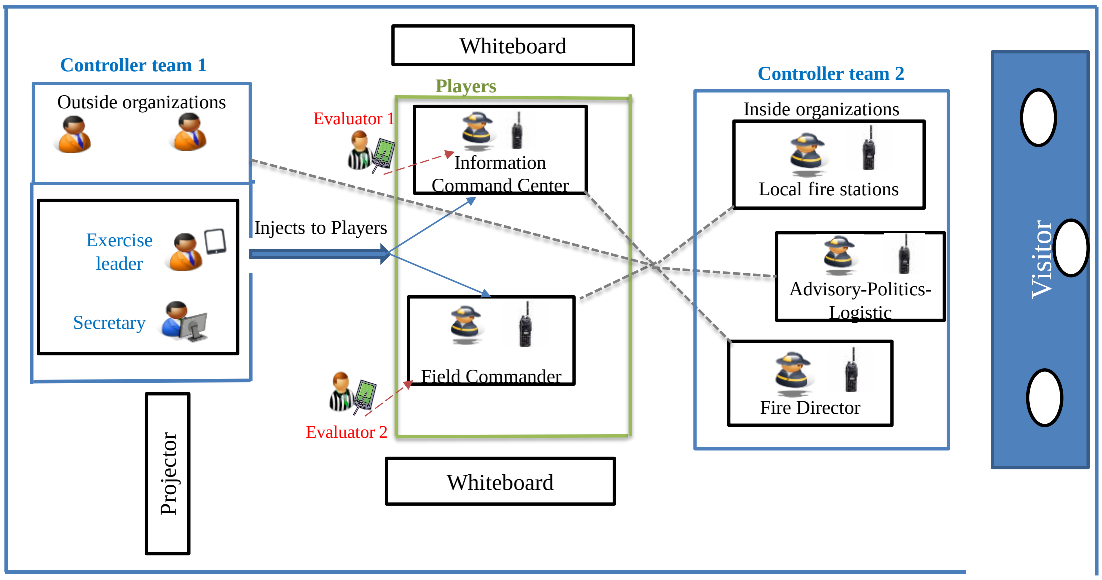


Figure 5-17. Layout of Haiphong Functional exercise

After the initial scenarios and information about first responders on site, ten injects were provided in each 3 or 5 mins to player groups via two-ways radio. The time schedule of key events in the Haiphong FX is provided in Table 5-14

Table 5-14. Time schedule of key events in the Haiphong FX

Time	Event
8:40-8:55	Overview of Haiphong FX: purpose, participants and schedule of FX
8:55-9:10	Exercise leader introduces the initial scenarios and first response of local forces and firefighting police

9:10-9:50	Ten injects are delivery to player groups in each 3 or 5 mins
9:50-10:30	Comment from visitors and hot-wash sections

5.7.2. Data and analysis methods

There were two player groups in Haiphong FX: Information Command Centre and Field Commander. Each player groups had three members and one two-ways radio. Two evaluators were in charge of confirming in Infogram Inc. system about start time and end time of each task conducted by player groups. For 10 injects in exercise, 38 tasks were fully recorded "elapsed time", "start time", and "end time".

As mentioned in Section 5.3.2.2, four task types are "request", "report", "inquiry", and "decision making". Difference from DMOC exercises, "decision making" in Haiphong FX is task that required members discussing inside their group then writing answers on whiteboard. Other three task types are classified similarity as DMOC exercises. The regression analysis for exercise data requires hypothesis of influence factors to task processing time. Influence factor related to observed data in Haiphong FX is shown in Table 5-15. Because some factors were not observed in the Haiphong FX, "exercise group" variable reflected several dimensions of each group such as member skills, member characteristics, and group cohesiveness. Independent variables in multiple regression model is explained in Table 5-16.

Table 5-15. List of factors affecting task-processing time

Potential factors of task-processing time		**Availability of data in Haiphong FX**
Individual-level	Member skills and training	*Not observed*
	Personality characteristics of team member	*Not observed*
Group-level	Structure of group	Communication domain
	Level of cohesiveness	*Not observed*
	Group size	Number of group member
Environmental-level	Task characteristic	Task types
	Level of heavy workload at a particular time	Number of simultaneously processed tasks in a group
Temporal phase	Stages of team project	Elapsed time
		Stage in communication structure

Table 5-16. Independent variables in multiple regression model

Variable	Variable types (unit)
Exercise group	Dummy variable Information Command Centre Field Commander
Communication domain	Dummy variable Within organization With outside organizations
Task type	Dummy variable Report Request Inquiry Decision making
Simultaneously processed tasks	Countable number (piece)
Elapsed time	Continues number (second)
Number of group member	Countable number (people)
Stage in communication structure	Dummy variable Stage 1 Stage 2

For cross sectional data in Haiphong FX, communication structure is visualized , and then using to create box plot, ANOVA test for statistical analysis.

5.7.3. Results

5.7.3.1. Visualization of communication structures by process mapping technique

From communication structure among groups in Haiphong FX (Figure 5-18), we can define different roles of each player group in two stages. In Stage 1, that is connect between 1st and 2nd processing group, Field commander played important roles to communication with Information Command Centre, Fire director and other organizations. In Stage 2, Information Command Center was important section to communication with other groups including Advisor, Politics and Logistic, Fire director, Local fire stations, and outside organizations. In general, four important groups in the exercise were Field Commander, Information Center, and Fire Director, and outside organizations. Information flow between Field Commander and Fire director were transfered through Information Command Center in most cases. Field Commander directly communicated with Fire Director to request higher level of commander in the exercise.

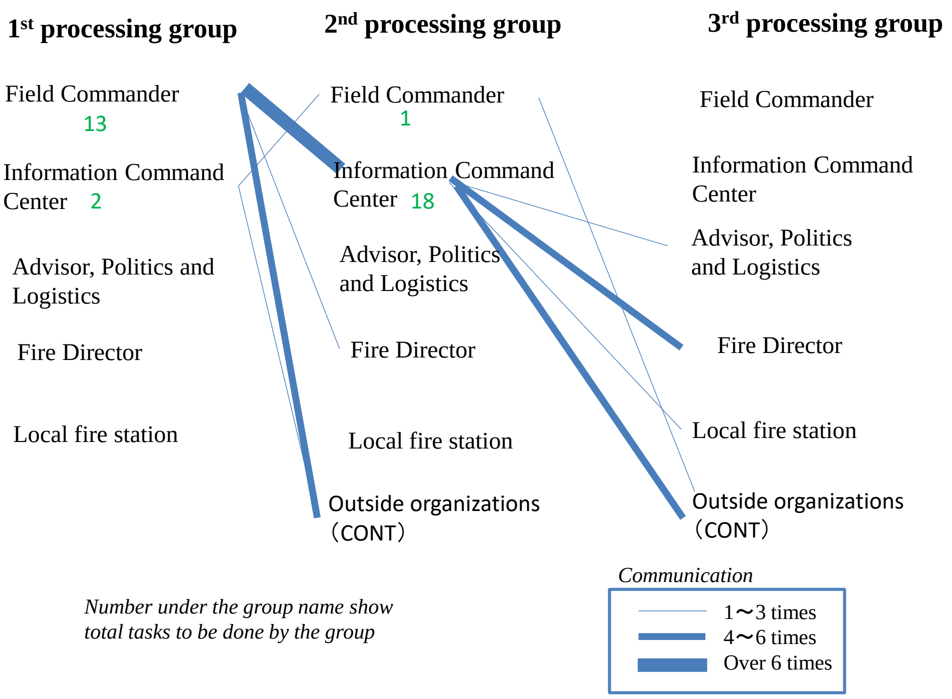


Figure 5-18. Communication structure among groups

An example of detail process map for one inject in Haiphong FX is shown in Figure 5-19. Information in detail process map includes implementation groups, content of tasks, links and task processing time by seconds. It provides detail information on communication structure in each inject for deeper discussion after exercise. For example, Field Commander need to do both task 2 and task 3, but which task should be priority to timely respond to situation.

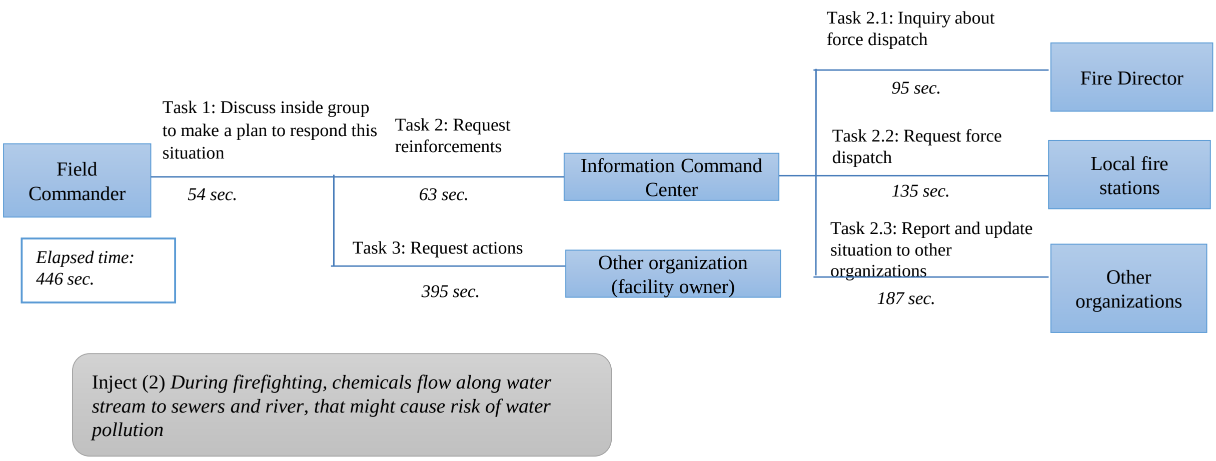


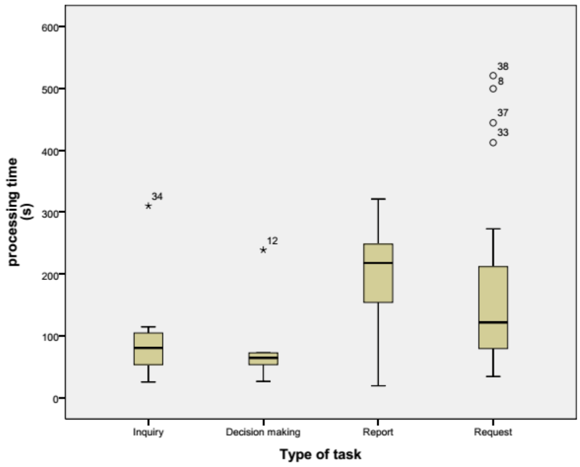
Figure 5-19. Communication structure among groups

5.7.3.2. Task performance analysis by statistical data analysis

From data recorded from 38 tasks in the Haiphong FX, box plots and ANOVA test were applied for understanding task processing time for each task type and group. Figure 5-20 summarizes the results of Haiphong FX. Box plots display the distribution of task processing time with minimum, first quartile, median, third quartile, and maximum value of the data.

ANOVA test did not detect statistically significant differences at the 5% level among the mean of task processing time across four task types or two player groups. Since no statistically significant differences after ANOVA test, we did not apply regression analysis for Haiphong FX.

Task types

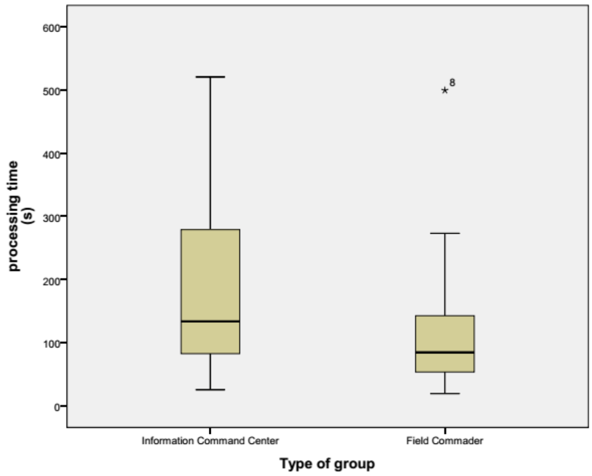


Task type	N	Mean (sec)	Std. Deviation (sec)	Min (sec)	Max (sec)
Inquiry	7	105.00	95.084	26	310
Decision making	5	91.60	84.213	27	239
Report	7	195.00	98.445	20	321
Request	19	184.63	160.393	35	520
Total	38	159.63	134.415	20	520

Statistical test	p-value
ANOVA	0.320

**. The difference is significant at the 0.05 level*

Exercise groups



Group	N	Mean (sec)	Std. Deviation (sec)	Min (sec)	Max (sec)
Information Command Center	20	188.75	142.99	26	520
Field Commander	18	127.28	119.86	20	499
Total	38	159.63	134.42	20	520

Statistical test	p-value
ANOVA	0.162

**. The difference is significant at the 0.05 level*

Figure 5-20. Task processing time according task types and group in Haiphong FX

Since box plots of task types and exercise groups have total six outliers on processing time, these tasks are deeper investigated. More details of tasks number 8, 12, 33, 34, 37, 38 are explained in Table 5-17.

Table 5-17. Outliners in Haiphong FX

Number /task types	Player group	Contents	Processing time (s)	Communication domain
8/Request	Field Commander	Field Commander requests facility owner to monitor the situation and have a solution to prevent chemicals flow to river.	499	Communicate outside organizations
12/Decision making	Field Commander	Discussion inside group to respond the case "three flanges on the pipe system of chemicals tank were destroyed, chemicals spilled out".	239	Discussion inside group
33/Request	Information Command Center	Information Command Center requests supports from nearby facilities on site because of expanding fire to another chemical tank.	412	Communicate outside organizations
34/Inquiry	Information Command Center	Information Command Center inquiries leader about information to report National Fire Department.	310	Communicate inside organization
37/Request	Information Command Center	Information Command Center requests local commune organizations to prevent and observe the possibility of fire spread by wind to residential areas	444	Communicate outside organizations
38/Request	Information Command Center	Information Command Center requests reinforcement from specialized chemical treatment force	520	Communicate outside organizations

Among total six outliers, four outliners were related to "request" tasks (8, 33, 37, 38). "Request" task refers to actions that a group send information to other groups to request certain actions toward goals. All of four tasks show communication links between player groups with outside organizations. It can be found that task processing time for requesting other organizations to do some actions took more time than inside

Haiphong FFPD. Results of time measurement become strong evidences of the fact that it takes time for mobilizing outside forces in emergency response.

Task 12 requests members in “Field Commander” to discuss inside group to have decision on problems about chemicals spill during firefighting. There were total five “decision making” tasks for player groups in the Haiphong FX. Among five tasks, four tasks were conducted by “Field Commander”. Task number 12 consumed longest time of the group to discuss and find solution than other three tasks. Among other three tasks, maximum processing time was 65 seconds, while task processing time of task 12 was 239 seconds. Time measurement result reveals demands of more practicing on this situation to faster responding process.

5.8. Summary of Chapter 5

Functional exercises are an important type of training that enhance information sharing through networks among emergency response organizations. Evaluation is an essential part of exercise management programs in order to consider how an exercise met its objectives and how emergency work was performed by players. Other benefits in exercise programs include promoting common understanding of the current status of the emergency management organization and providing lessons learnt to encourage organizational improvement. In practice, checklists, questionnaires, and interviews are common tools for collecting information for exercise results. Our study gave greater consideration to processing time of tasks for quantitatively evaluating group performance in functional exercise. Task processing time is continuous data that provides advantages than discrete or qualitative data to get understand better picture of what's going on inside exercise.

In this chapter, I used knowledge of time studies in the industrial domain, communication studies and team performance studies to interpret the meaning of task processing time observed in functional exercise. Methods, and techniques to visualize and analyze data collected from functional exercise have been developed. Three case studies including two cases for Japanese organizations, one case for Vietnamese organization were discussed and analysed.

Case study 1 focused on data of two DMOC exercises in 2015 that were conducted for medical headquarters’ teams in Kitakyushu city. Visualization of communication structures demonstrated important communication links among medical partners in earthquake. Time analysis found several features of players' communications that would have been difficult to find without the method. The task processing time in "Decision making" and "Site group" was longer than other task types and in other groups in October. Tasks implemented in the first stage consumed more time than tasks in the second stage. These differences, however, vanished in November since there were more outliers in task processing time. I then compared processing times of the same tasks between the October and November exercises as panel data. Results from combined data of two DMOC exercises shows statistical differences among task processing of stages and communication domains. Comparison on task processing time of each repeated tasks revealed that members in the Base Hospital Group took more time to finish their tasks in the first stage in November than in October despite the repetition of similar exercises by almost the same players. These results provide useful information for emergency managers to understand the status of his/her organization and help writing an insightful after action review.

Case study 2 is another example for DMOC exercise in 2016. As extension from exercise program in 2015, the 2016 DMOC exercise had two sections: Section 1 for DMOC establishment, section 2 for JMATs activities at shelters. Together with DMOC groups, Local medical association and three JMATs joined in the exercise. From data sources of the exercise, I created the communication structures for two sections that highlighted links between coordination group and other stakeholders in section 1, and links between local medical association and three JMATs in section 2. The quantitative ANOVA demonstrated statistically significant differences between the mean values of task processing time across groups. Deeper investigating processing times of JMATs for each type of tasks clearly show that JMAT 3 took more time in the exercise than other JMATs. The results of time analysis contributed to a deeper discussion among organizations after the exercise. By addressing the lessons learned from the functional exercise, organizations can develop appropriate solutions to improve their networks during emergency events.

Case study 3 used data from the functional exercise in 2018 for Haiphong FFPD. This was the first time of conducting functional exercise for Haiphong FFPD and the first time of doing KFEX style in Vietnam. Before that event, task processing time is not measured in functional exercise, communication structure among groups in exercise is not drawn, and evaluation section is normally conducted by qualitatively comments from leaders. By using data from the Haiphong FX in case study 3, communication structures were created that providing overview of relationship among groups in the exercise. Although ANOVA test did not detect statistically significant differences at the 5% level among the mean of task processing time across four task types or two player groups, deeper discussion on outliers revealed clues to emergency managers. Communication of Haiphong FFPD with outside organizations to request some actions, and decision making on problems about chemicals spill during firefighting were found as issues that need to be further discussion to shorter processing time.

6. CONCLUDING REMARKS

6.1. Summary of key issues in the thesis

In the context of climate change and economic development, emergency management of each country need to be enhanced to better protect citizens. Although emergency management should be construed according to history of disasters, culture of society and government structures, many lessons from different countries are useful for mitigate, prevent, respond and recovery from emergencies. Reducing communication failures from human factors in emergency management is one of approach to support for timely and effectively emergency response.

PDCA (Plan-Do-Check-Act) cycle is useful management method that currently is applied in management such as project management, industrial management. In emergency management with abnormal conditions of organization structures and resources, exercise programs play important roles to practice, evaluate and improve emergency functions before emergency or disasters. Table-top and functional exercises are two types of emergency exercise for addressing communication issues. More benefits from these exercises should be used for exercise participants and managers in countries, including Vietnam.

The review of Vietnamese emergency management provides information on policy development and governmental structures to manage different types of emergencies. From 2013 onwards, it is observed development of more legal documents for addressing man-made emergencies cases. Since emergency management system in Vietnam relies on authorities and communities at local levels, many different stakeholders are involved in emergency management systems. Improving common understanding and enhancing communication among stakeholders become core issues. Although many information can learn for improving communication from exercise events, lack of mention in Vietnamese legal documents on conducting table-top and functional exercise program.

In exercise design, The Analytic Hierarchy Process is the suitable approach to combine opinions in a planning team for choosing exercise topics. Hazards identification is useful for understanding the potential risks as well as establishing fundamental to design exercises. After applying AHP in environmental and fire-related emergency at port areas, some key elements for exercise topics were revealed. Coordination among stakeholders and equipment to alert or monitor situations are two of important elements in both cases.

In exercise evaluation, there are different objectives for table-top and functional exercise. Since table-top exercise encourage discussion among groups, organizations, the evaluation program is better to contribute share knowledge and information on communication structures among participants. By understanding more details on relationship among stakeholders, it supports to prevent communication failures by human factors in real emergencies. Emergency mangers also have more data to find solutions to enhance communication among responders. Functional exercise is more complicated exercise type than table-top exercise, that is useful to evaluate and test communication among stakeholders. Typical evaluation program collect qualitative data from checklists and comments of evaluators during functional exercises. Comparing with quantitative data, qualitative data has its limitation for analysing performance of players. Therefore, observing and analysing time-element in evaluation programs are advantages to find out quantitative evidence about player's performance in functional exercise. The approach has been proposed in this dissertation by using serval methods of process mapping technique, and task performance analysis in time-study for analysing data. Relationship among time, groups, and tasks has been analysed. Some important findings can not be found without use of time elements in evaluation program.

6.2. Further Implications

There would be some suggestions for further extending results from the thesis. It is necessary to follow building block approach for exercise program in emergency management. From reviewing situation on exercise program in Vietnam, drills are popular events for emergency responders. Meanwhile lack of experiences on table-top exercise and functional exercise. My suggestion is doing some table top exercise then improving to functional exercise. After exercises, communication structures should be clearly defined for sharing common understanding among participants. This issue is very important in emergency to quick and appreciate actions and ensure safety for responders.

For evaluation program on functional exercise, the observed data in case studies were mainly focused on measuring time element to find quantitative evidences in the exercise. However, how well tasks are performed, and the speed of execution are both important in emergency response. Typical evaluation methods are focused how well tasks are performed but limited consideration on detail time data on exercise. To comprehensively describe the quality of an action, it needs to consider both quality metric and time metric. Therefore, both qualitative and quantitative methods are necessary to observe team performance in exercise evaluation programs. By considering the time element in addition to the qualitative information obtained by doing checklists, score sheets, and open ended questions, we can be more accurate at answering four questions regarding exercise evaluation: what happened, why and when it happened, and how it should be improved. Exercise managers can decide objective of exercise program, then select appropriate evaluation methods.

Another benefit of measuring time in exercise program is that enables longitudinal data for deeper analyse and compare task performances. The length of time for processing each task in a standard environment may be used to setup a standard unit processing time for completing those tasks and then a deadline for the entire workflow may be reasonably defined. This information on task processing time would help making standard operating procedures of emergency management more practical. Moreover, one of issues about communication in emergencies is priority to conduct tasks under time and resource constraints. Analyzing task processing time of core emergency management groups in an exercise can contribute to addressing this issue.

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